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STUDIES OF HUMIFICATION OF TRIANTHEMA MONOGYNA

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SUMMARY

Trianthema monogyna was humified alone and also in soil and studies of humus and microbes were made. During humification conditions develop whereby stabilised nitrogen is slowly transformed to mineralised nitrogen. This mineralised nitrogen may be a suitable source of nitrogen to plants.

Trianthema monogyna (Vernacular name in Agra is Vishakhaphara) is a prostrate herbaceous weed widely distributed in India. In contrast to various nodule bearing leguminous plants, where the nitrogen content increases during the life time of the plant, in the case of Trianthema monogyna nitrogen increases when the plant is humified under aerated conditions. This increased nitrogen is found to be in a stabilised form from which steady mineralisation takes place making possible nitrogen available to the crop plants at a steady rate.

The plant was dried under shade, finely pulverised and then humified under aerated conditions. Variations in various forms of nitrogen and carbon were studied. Humus determinations were made to have an idea about the stable nature of the decomposing mass. pH and microbial counts were made to study their relationships with carbon and nitrogen. When organic matter is humified various changes of complex nature take place.[1] Changes in C/N ratio give a clue as to the nature of the humus and microbial decomposition. When C/N ratio is greater than five, formation of ammonia is delayed[2] and only that nitrogen is mineralised which is in excess of microbial needs. According to Dhar and co-workers, nitrogen is rapidly fixed when C/N ratio is greater than ten.[3] But in this case it starts fixing nitrogen at the mean C/N ratio of 8·5 though the rate of fixation is slow.

EXPERIMENTAL

Finely pulverised and sieved organic matter and soil were mixed in the ratio of 1 : 20 by weight and it has been referred to as treated soil. It was humified under shade at 15% moisture level under aerated conditions. Soil and organic matter were also humified separately. At intervals of ten days the air dried samples were studied for organic carbon, total nitrogen, mineralised nitrogen as nitrate and ammonical nitrogen, organic nitrogen, C/N ratio and at intervals of 50 days for humus. Estimations were carried out in triplicates and whenever there were great deviations more estimations were performed.

Organic carbon was determined by Black and Walkley's rapid titration method.[4,5] The values obtained experimentally were multiplied by the factor 1·30 to get the absolute values of organic carbon. Percentage of carbon obtained by Black and Walkley's rapid titration method is 23% less than the one obtained by dry combustion method according to Walkley and Black. So, the percentages of carbon obtained by this method are multiplied by 100/77 or 1·30 to get absolute values of organic carbon. Total nitrogen content was estimated by a modified Kjeldahl's method[6] using sodium thiosulphate. Organic nitrogen was calculated by substracting mineralised nitrogen, determined as nitrate nitrogen and ammonical nitrogen, from total nitrogen. Nitrate nitrogen was determined by leaching the sample with water, destroying the organic matter by alkaline potassium permanganate and then reducing the nitrates by Devardas alloy and tapping out ammonia by means of an efficient splash head in standard sulphuric acid. Ammonical nitrogen was estimated by digesting with 3N hydrochloric acid and then ammonia was tapped out by heating with freshly ignited magnesia.

Humus was determined by N/2 sodium hydroxide digestion method (Schreiner and Shorey[7]) as alkali-soluble, sulphuric acid-insoluble humic acid and as alkali-soluble, sulphuric acid-soluble fulvic acid. As the humus determined by various methods differs, it was also determined by digestion with 5% ammonium hydroxide solution (Hilgrad and Jaffa[7]) as ammonia soluble, hydrochloric acid-insoluble humus corresponding to humic acid and as ammonia-soluble, hydrochloric acid-soluble portion corresponding to fulvic acid. pH was determined by Northrup pH meter. Microbial counts were made by agar plate method using Dox agar for fungal counts, Ashby's agar for azotobacter counts and Thornton's agar for total bacterial counts.

ABBREVIATIONS

O. =Organic matter
T. =Treated soil
S. =Soil

DISCUSSION

On humification carbon undergoes heavy losses in the organic matter. It shows the unstable nature of various compounds present in the plant material. In the treated soil there is enough loss but less so than the organic matter where there is high percentage of the unstable material as compared to the treated soil. In the soil loss is followed by gain, a point suggesting that humus is susceptible to slight decomposition which process may alternate with microbial synthesis of organic substances by photo-autotrophic and chemo- autotrophic bacteria.

In the organic matter nitrogen changes are small and show fluctuations both above and below the initial level; this is because for every one part of

TABLE 1

Percentage of organic carbon and organic nitrogen & C/N ratio

S. No.	Time of sampling	Organic carbon			Organic nitrogen			C/N ratio		
		O.	T.	S.	O.	T.	S.	O.	T.	S.
1.	Zero time	33·6	2·34	0·754	3·3	0·25	0·103	10·18	9·36	7·32
2.	10 days	32·1	2·27	0·718	3·4	0·25	0·090	9·44	9·08	7·98
3.	20 ,,	31·4	2·22	0·670	3·65	0·24	0·107	8·60	9·25	6·26
4.	30 ,,	30·3	2·16	0·690	3·65	0·25	0·115	8·30	8·64	6·00
5.	40 ,,	29·1	2·12	0·617	3·5	0·22	0·148	8·31	9·64	4·17
6.	50 ,,	28·4	2·10	0·702	3·45	0·24	0·138	8·23	8·75	5·09
7.	60 ,,	28·2	2·09	0·705	3·45	0·27	0·135	8·17	7·74	5·22
8.	70 ,,	27·1	2·07	0·734	3·45	0·25	0·128	7·86	8·28	5·73
9.	80 ,,	26·4	1·99	0·755	3·15	0·26	0·121	8·38	7·65	6·24
10.	90 ,,	25·4	1·96	0·745	3·2	0·25	0·107	7·94	7·84	6·96
11.	100 ,,	26·0	1·99	0·755	3·2	0·27	0·100	8·13	7·37	7·55

TABLE 2

Percentage of ammonical & nitrate nitrogens

S. No.	Time of sampling	Ammonical nitrogen			Nitrate nitrogen		
		O.	T.	S.	O.	T.	S.
1.	Zero time	0·124	0·010	0·0049	0·248	0·022	0·011
2.	10 days	0·080	0·008	0·0041	0·241	0·019	0·010
3.	20 ,,	0·068	0·007	0·0032	0·238	0·023	0·010
4.	30 ,,	0·080	0·010	0·0048	0·224	0·024	0·011
5.	40 ,,	0·093	0·013	0·0067	0·214	0·031	0·0125
6.	50 ,,	0·100	0·014	0·0058	0·150	0·031	0·010
7.	60 ,,	0·125	0·012	0·0063	0·131	0·032	0·010
8.	70 ,,	0·159	0·011	0·0055	0·106	0·038	0·010
9.	80 ,,	0·137	0·011	0·0045	0·123	0·037	0·010
10.	90 ,,	0·152	0·011	0·0055	0·145	0·039	0·011
11.	100 ,,	0·175	0·012	0·0068	0·175	0·039	0·011

TABLE 3

Percentage of humic matter by Schreiner & Shorey method

S.No.	Time of sampling	Humic acid			Fulvic acid		
		O.	T.	S.	O.	T.	S.
1.	Zero Time	4·35	0·53	0·260	9·75	4·52	3·01
2.	50 days	11·5	0·82	0·221	10·00	4·81	1·83
3.	100 days	41·3	2·41	0·413	18·81	5·34	2·11

TABLE 4

The corresponding values of humic matter by Hilgard & Jaffa method

S.No.	Time of sampling	Portion corresponding to humic acid			Portion corresponding to fulvic acid		
		O.	T.	S.	O.	T.	S.
1.	Zero Time	3·21	0·058	0·024	5·01	2·13	1·51
2.	50 days	8·72	0·086	0·020	5·30	2·31	0·91
3.	100 days	30·3	0·263	0·041	9·64	2·56	1·03

TABLE 5

**Ratio of humic matter by two methods*

S.No.	Acid insoluble humus			Acid soluble humus		
	O.	T.	S.	O.	T.	S.
1.	1·35	9·14	10·83	1·95	2·12	2·00
2.	1·32	9·53	11·05	1·89	2·08	2·00
3.	1·36	9·16	10·07	1·95	2·09	2·05

* The humus by Schreiner and Shorey method has been divided by the humus by Hilgard and Jaffa method.

TABLE 6

pH at different periods of humification

S.No.	Time of sampling	pH values		
		O.	T.	S.
1.	Zero Time	6·05	7·15	7·8
2.	10 days	6·9	8·15	6·8
3.	20 ,,	8·1	8·4	8·0
4.	30 ,,	8·65	8·15	8·05
5.	40 ,,	8·6	7·8	8·05
6.	50 ,,	8·95	8·05	7·9
7.	60 ,,	9·1	8·4	7·9
8.	70 ,,	...	...	...
9.	80 ,,	9·45	8·5	7·9
10.	90 ,,	9·45	8·3	7·85
11.	100 ,,	9·45	8·0	7·8

TABLE 7

Microbial counts per gram of the humifying material

S.No.	Time of sampling	Total bacteria/10^7			Azotobacter/10^6			Fungi/10^3		
		O.	T.	S.	O.	T.	S.	O.	T.	S.
1.	Zero Time	6	8·6	3	24	7	7	40	9	8
2.	20 days	25	6	2·7	73	23	9	30	6	9
3.	40 days	25	2·3	1·2	62	6	2	70	4	7
4.	60 days	8	1·25	1·9	43	15	1	170	6	4
5.	80 days	12·5	6·7	1·5	27	10	3	110	4	4
6.	100 days	10	8·9	1·3	41	17	4	30	16	5

nitrogen about eight parts of carbon are lost except for certain stages. The behaviour of the soil is very peculiar but, we see that the treated soil behaves intermediately. The organic nitrogen behaves similar to the total nitrogen which shows that large percentage of the organic nitrogen masks the contributions to the percentage of total nitrogen of the mineralised nitrogen which is present in very minute amounts.

C/N ratio (vide table 1) which is the ratio of the organic carbon to the organic nitrogen, states the extent and stage of humification. In case of the organic matter, it goes down a little and stabilizes at about 8. In the soil the complex behaviour of C/N raito can be explained by the existance of a complex microbial flora working in various directions. Treated soil shows a steady downfall till C/N ratio reaches the value of 7·8 nearly, after two months of humification.

The organic matter, at first, shows a decline in the mineralised nitrogen (vide table 2) which begins to be fixed after two months: The treated soil shows a steady rise of the mineralised nitrogen. The soil has a somewhat fluctuating behaviour. In all the three cases—the organic matter, the treated soil and the soil—the nitrate nitrogen which is generally twice or sometimes thrice the ammonical nitrogen and is the main source of nitrogen to the plants, seems to be the main contributor to the behaviour of the total mineralised nitrogen. The ammonical nitrogen, at first, shows a decline and then increase even above the initial level in all the three cases.

From the tables 3 and 4, we see that after 50 days there is rapid increase of the humic matter. This indicates that in the initial 50 days it is mostly decomposition of the compounds of unstable nature like the carbohydrates and after that the organic matter becomes more or less stable leading to the formation of the humic matter partly formed by the activity of micro-organisms. From the comparison of the tables 3 and 4 as done in the table 5, it may be noted that the acid-soluble humus by Schreiner and Shorey method is twice the quantity of the one obtained by Hilgard and Jaffa method. As regards the acid insoluble portions of the humic matter the ratio is surprisingly constant for any one particular type of the substance although it differs much for different substances. This practically proves that the more drastic treatment of the organic matter with caustic soda (Schreiner and Shorey method) extracts greater amounts of the humic matter than the milder treatment with ammonia (Hilgard and Jaffa method).

During decomposition and humification, pH (vide table 6) shows a general tendency towards increase except in case of the soil where there is negligible organic matter; maximum pH for the organic matter being 9·45, for the treated soil 8·5 and for the soil 8·05. It shows that during decomposition of this particular plant under aerated conditions, basic substances are mostly liberated. From the table 7, it can be concluded that where there is more organic matter, there more microbes flourish. In case of the organic matter all the three types of microbial counts show, at first, a tendency to increase and then to decrease. In the treated soil Azotobacter and fungal counts have finally shown an increase than the initial number. In the soil, due to lack of organic matter all the types of microbes have shown a tendency towards diminution in their number.

Furthermore when re-examining the tables in the light of one another although no generalisations can be drawn, still some interesting points may be noted. As the humification proceeds, the pH increases steadily, at first rapidly and then slowly both in the organic matter and the treated soil. The various microbial counts in organic matter have shown a tendency towards increase when the pH is about 8·5. After few weeks when the pH value goes beyond 8·5, there is downfall in microbial counts. In the treated soil the tendency of microbial counts is towards increase throughout as the stable optimum pH of about 8·5 is not reached. In the soil where pH is very low microbes diminish in their number although other factors like the scarcity of their food in the soil may also be an important factor causing diminution in their number.

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DEVELOPMENT OF FEMALE GAMETOPHYTE AND ENDOSPERM IN PLANTAGO CORONOPUS L.

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INTRODUCTION

The genus *Plantago*, embracing about 200 species (Bailey 1950 Lawrence 1951, Rendle 1952, and Hutchinson 1959), is a member of the family Plantaginaceae growing throughout the world (Willis 1950). This genus has been much acclaimed due to its medicinal, economic and other commercial properties (Le Maout and Decaisne 1876, Watt 1892, Chopra 1932, Kirtikar and Basu 1935, Bailey 1950, Gundersen 1950, Dastur 1951, Nadkarni 1954, Chopra *et al* 1956, Gillespie 1959, Watt and Brandwijk 1962). Further improvement in these properties can possibly be made through breeding provided one knows in detail the different life processes of the plant. The earlier embryological literature on the Plantaginaceae is meagre and has been summarised by Schnarf (1929, 1931) who reports four uninucleate micropylar endosperm haustoria and a single binucleate chalazal haustorium in *Plantago*. Cooper (1942), on the other hand, mentions only two micropylar endosperm haustoria in *P. lanceolata.*

MATERIAL AND METHODS

Flowers and fruits of all ages were fixed in formalin-acetic-alcohol, from plants growing in National Botanic Gardens, Lucknow. They were dehydrated through tertiary-butyl alcohol series and embedded in paraffin. Serial sections of the order of 8-10μ were cut, stained in Heidenhain's iron-alum haematoxylin, as well as safranin—fast green combination; the former, however, produced better result.

OBSERVATION

The plant is an annual herb which flowers in winter. The inflorescence is a long spike borne at the top of a long, leafless, axillary stalk. Each flower is sessile, bracteate, complete, actinomorphic, tetramerous, hermaphrodite and hypogynous. The gynoeceum consists of a bicarpellary, bilocular, syncarpous ovary having two or three ovules in each loculus and a long feathery style with diffused stigma.

Ovule is ana-campylotropous (Terminology after Bocquet 1959), unitegmic and tenuinucelate. To start with a meristematic outgrowth on the placenta takesplace place laterally initiating the ovular primordium, By the time the nucellus and integument become distinct the ovule curves down and becomes anatropous. Further growth of the integument at the micropylar and chalazal regions makes the ovule ana-campylotropous with a long micropyle (Fig. 1).

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MEGASPOROGENESIS AND FEMALE GAMETOPHYTE

A single, hypodermal archesporial cell (Fig. 2) functions directly as the megaspore mother cell (Fig. 3). It shows considerable elongation before it undergoes the normal meiotic-mitoses to form a dyad (Fig. 4) and finally a linear tetrad of megaspores (Fig. 5) which are surrounded by a single layer of the nucellar epidermis. The three megaspores towards the micropylar end degenerate while the chalazal one functions (Fig. 6) producing successively 2- (Fig. 7), 4- (Fig. 8) and finally an 8-nucleate embryo sac (Fig. 9). It thus shows a Polygonum type of embryo sac development (Maheshwari 1950). The nuclei organise into an egg apparatus, three antipodal cells and two polar nuclei that lie close to the egg (Fig. 9). The embryo sac at this stage is slightly curved towards placenta with a comparatively broad middle portion and narrow ends. Both the polar nuclei fuse forming a large secondary nucleus before the entrance of pollen tube into the embryo sac (Fig.10).

ENDOSPERM AND BEHAVIOUR OF ITS HAUSTORIA

The primary endosperm nucleus divides much earlier than the zygote. Its first division is followed by a transverse wall separating the micropylar chamber from the chalazal chamber (Fig. 11). The chalazal chamber undergoes a nuclear division and functions directly as a binucleate haustorium. A chalazal endosperm haustorium of the same type has also been reported by Schnarf (1917, 1929, 1931) and Cooper (1942). The micropylar chamber, on the other hand, undergoes two successive longitudinal divisions at right angles to each other forming four cells in a single tier (Figs. 12, 13). A single transverse division takes place in each of these cells resulting in two tiers of four cells each (Fig. 14). The cells of the upper tier grow considerably and function as four uninucleate micropylar haustoria. The cells of the lower tier, on the other hand, divide repeatedly, followed by wall formation at the end of each division, resulting in the formation of the main endosperm. Fig. 15 shows a transverse section of the micropylar region of the ovule showing four distinct cells of the micropylar endosperm haustoria. A similar observation has also been made by Schnarf (1917) in *P. media.* Further growth of the main body of the endosperm takes place asymmetrically as a result of which both micropylar and chalazal haustoria move towards the placenta and lie very close to it (Fig. 16). In doing so the aggressive haustoria consume a major part of the integumentary cells.

SUMMARY

Ovule is ana-campylotropous, unitegmic and tenuinucellate.

A single archesporial cell functions as megaspore mother cell directly and produces a linear row of megaspore tetrad of which only the chalazal one functions.

Development of embryo sac conforms to the Polygonum type.

Endosperm is Cellular. There are four uninucleate micropylar endosperm haustoria and a single binucleate chalazal endosperm haustorium.

I am greatly indebted to Dr. Bahadur Singh for guidance and to Prof. K. N. Kaul, F.L.S., Director, National Botanic Gardens, Lucknow, for encouragement and facilities. My thanks are also due to Dr. S. P. Bhatnagar for immense help during these investigations and to C.S.I.R. for the award of Junior Research Fellowship.

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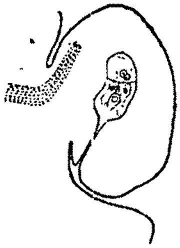

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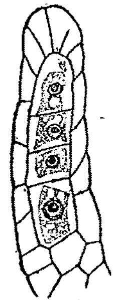

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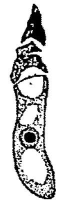

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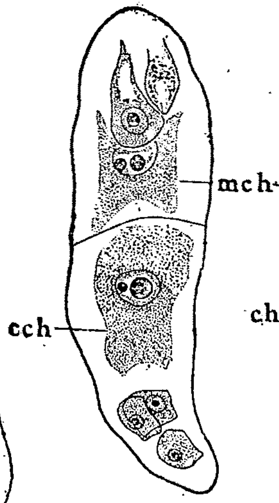

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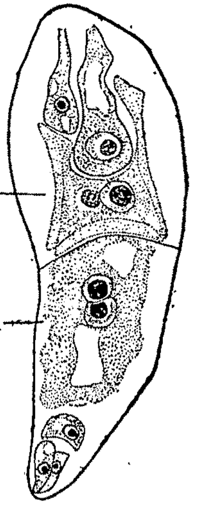

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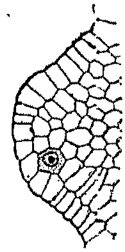

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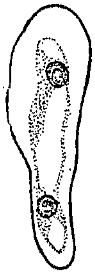

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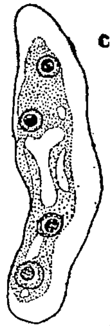

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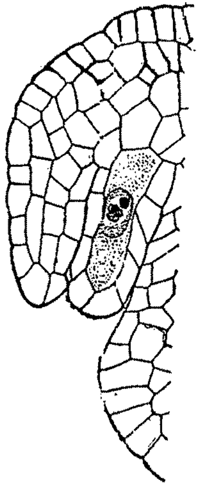

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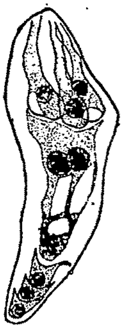

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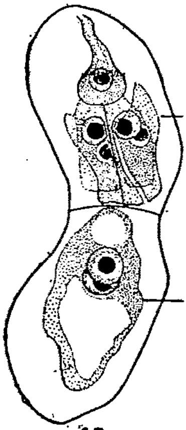

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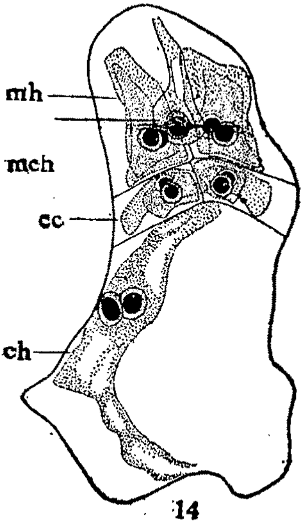

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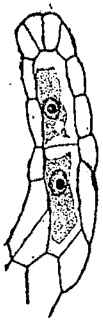

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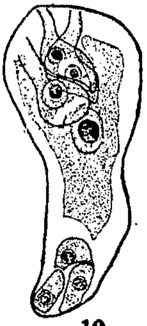

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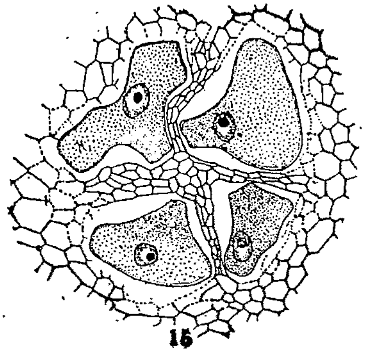

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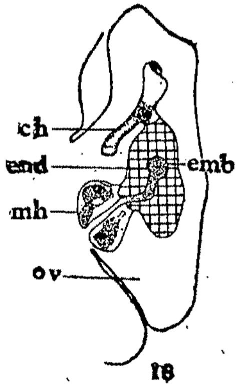

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Text Figs. 1-16. Megagametogenesis and endosperm of *P. coronopus*.

[*cc*-chalazal chamber, *cch*-chalazal haustorium, *emb*-embryo, *end*-endosperm, *mch*-micropylar chamber, *mh*-micropylar haustorium, *ov*-ovule, *z*-zygote]

Fig. 1. L.s. post fertilised ovule showing ana-campylotropous condition. x95·4.

Fig. 2. L.s. ovular primordium showing an archesporial cell. Note : the nucellus and integument are undefined so far. x320.

Fig. 3. L.s. ovule with a megaspore mother cell showing unitegmic and tenuinucellate condition. x320.

Figs. 4,5. Dyad and megaspore tetrad respectively embedded in the nucellar epidermis only. x320.

Fig. 6. A megaspore tetrad showing the chalazal megaspore functioning. x320.

Figs. 7,8. 2- and 4-nucleate embryo sacs. x320.

Fig. 9. An organised 8-nucleate embryo sac. x320.

Fig. 10. A mature embryo sac showing a large secondary nucleus. x320.

Fig. 11. Micropylar and chalazal endosperm chambers formed after the first division of the primary endosperm nucleus. x320.

Figs. 12,13. Embryo sacs showing two successive longitudinal divisions of the micropylar chamber of the endosperm and a nuclear division in the chalazal chamber. x320.

Fig. 14. Embryo sac showing a three chambered endosperm. Note : all four cells of the uppermost tier are the initials of the micropylar endosperm haustoria. x320.

Fig. 15. T.s. micropylar region of the ovule showing four distinct micropylar endosperm haustoria. x60.

Fig. 16. L.s. almost mature ovule showing both micropylar and chalazal haustoria in the vicinity of the placenta. x47·6.

UNSTEADY TURBULENT FLOW IN A PLANE WAKE BEHIND A SYMMETRICAL CYLINDER IN COMPRESSIBLE FLUID

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Agra College, Agra.

INTRODUCTION

The velocity distribution at a considerable distance downstream in the wake behind a symmetrical cylinder in incompressible fluid has been calculated by Schlichting[1] (1930) on the momentum transfer theory. An attempt was made by Tollmien[2] (1933) to find the velocity distribution in a wake with Kármân's form for l, l being the mixture length. Goldstein[3] (1938) extended it for the wake behind a body of revolution on both the momentum transfer and the vorticity transfer theories. The case they considered was when the motion is steady. Ray[4] (1947) considered a special type of non-stationary turbulent wake.

The problems of steady turbulent flow in a compressible fluid have been studied by some authors. Abramovich[5] (1944) considered the case of the mixing of a parallel stream with the adjacent medium at rest and Görtler[6] (1952) considered the same problem on assumptions due to Reichard's that the exchange coefficient is constant over each cross section of the mixing zone for free turbulence. Pai[7] (1949) took up the problem of plane jet exhausting into uniform streams. Pai[8] (1952) extended the case to the problem of an axially symmetrical jet. Ray[9] (1954) studied the problem of steady turbulent flow in a plane wake in compressible fluid using both Prandtl's mixture length theory and Reichardt's theory of free turbulence. The fundamental equation of motion was simplified under the assumption of small perturbations. For free turbulence Prandtl's number was taken to be unity.

In a recent paper[10] the present author studied the unsteady turbulent flow in a plane wake behind a symmetrical cylinder in compressible fluid. He assumed all the quantities independent of x, and therefore neglected all the derivatives with respect to x.

In this paper the unsteady turbulent flow in a plane wake behind a symmetrical cylinder in compressible fluid has been studied without assuming any quantity independent of x, and therefore derivatives with respect to x have not been neglected. The velocity distribution has been obtained and the heat content, i, has also been obtained in terms of velocity. Analysis is not based on von Mise's transformations as was in reference.[10]

BASIC EQUATIONS

Let a cylinder with generators at right angles to the undisturbed flow be placed in a stream, the cylinder having a plane of symmetry parallel to the undisturbed flow. Let x-axis be along the axis of the wake, the origin being some specified point in the neighourhood of the cylindrical obstacle. Let u_0 be the undisturbed velocity and (u, v) the components of the mean velocity in the wake. The pressure is assumed to be nearly constant across a section of the wake so that the pressure gradient may be neglected. Transverse velocity will be small compared with the longitudinal velocity. The equation of motion in the x-direction is

$$\rho \frac{\partial u}{\partial t} + \rho u \frac{\partial u}{\partial x} + \rho v \frac{\partial u}{\partial y} = \frac{\partial}{\partial y}\left(\varepsilon\rho \frac{\partial u}{\partial y}\right) \quad ..(1)$$

where ρ is the mean density and ε is the exchange coefficient of the turbulent flow.

The equation of energy is

$$\rho \frac{\partial i}{\partial t} + \rho u \frac{\partial i}{\partial x} + \rho v \frac{\partial i}{\partial y} = \frac{\partial}{\partial y}\left(\varepsilon\rho \frac{\partial i}{\partial y}\right) + \varepsilon\rho \left(\frac{\partial u}{\partial y}\right)^2 \quad ..(2)$$

where i is the heat content.

The equation of continuity is

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} = 0 \quad ..(3)$$

Let us assume that v is small and for a first approximation u is replaced by u_0 and also ρu by ρu_0, such assumption has been made by Goldstein[11] (1950) also for a steady turbulent wake behind a symmetrical cylinder for first approximations. With these assumptions equations (1), (2) and (3) become

$$\rho \frac{\partial u}{\partial t} + \rho u_0 \frac{\partial u}{\partial x} = \frac{\partial}{\partial y}\left(\varepsilon\rho \frac{\partial u}{\partial y}\right) \quad ..(4)$$

$$\rho \frac{\partial i}{\partial t} + \rho u_0 \frac{\partial i}{\partial x} = \frac{\partial}{\partial y}\left(\varepsilon\rho \frac{\partial i}{\partial y}\right) + \varepsilon\rho \left(\frac{\partial u}{\partial y}\right)^2 \quad ..(5)$$

$$\frac{\partial \rho}{\partial t} + u_0 \frac{\partial \rho}{\partial x} = 0 \quad ..(6)$$

Assuming that

$$\rho(x, t) = \rho(x) f_1(t), \quad l^2(x, t) = l^2(x) f_3(t)$$
$$u(x, y, t) = u(x, y) f_2(t) \quad ..(7)$$

equation (6) gives

$$\rho(x) f_1'(t) + u_0 f_1(t) \rho'(x) = 0$$

where dashes denote differentiations with respect to the variables given in the brackets against them.

Hence

$$\frac{f_1'(t)}{f_1(t)} + u_0 \frac{\rho'(x)}{\rho(x)} = 0 \quad ..(8)$$

To find the values of $f_1(t)$ and $\rho(x)$, we apply the method of separation of variables.

Equation (8) is satisfied if we put

$$\frac{f_1'(t)}{f_1(t)}=u_0\lambda,\quad \frac{\rho'(x)}{\rho(x)}=-\lambda \qquad ..(9)$$

Integrating (9) we get

$$f_1(t)=A_1 e^{u_0\lambda t},\quad \rho(x)=A_2 e^{-\lambda x}$$

Hence

$$\rho(x, t)=A\, e^{\lambda(u_0 t-x)} \qquad ..(10)$$

Initially when $t=0$, $x=0$, $\rho=\rho_0$, therefore

$$\rho(x, t)=\rho_0\, e^{\lambda(u_0 t-x)} \qquad ..(11)$$

Thus density has been completely determined as a function of t and x.

Now according to Prandtl's theory

$$\varepsilon=l^2\left|\frac{\partial u}{\partial y}\right|$$

where l is the mixture length.

Substituting (7) and (11) in (4) we get

$$\rho_0 e^{\lambda(u_0t-x)}\, u(x,y)\frac{\partial f_2}{\partial t}+\rho_0 u_0 e^{\lambda(u_0t-x)} f_2\frac{\partial u}{\partial x}(x,y)$$

$$=-2\rho_0 f_2^2 f_3\, e^{\lambda(u_0t-x)}\, l^2(x)\,\frac{\partial u}{\partial y}\,\frac{\partial^2 u}{\partial y^2}$$

negative sign has been taken on the right because $\frac{\partial u}{\partial y}$ is negative when y is positive. Thus above equation becomes

$$u\frac{\partial f_2}{\partial t}+u_0 f_2\frac{\partial u}{\partial x}=-2f_2^2 f_3\, l^2(x)\frac{\partial u}{\partial y}\,\frac{\partial^2 u}{\partial y^2} \qquad ..(12)$$

Equation (12) will be independent of time if

$$\frac{\partial f_2}{\partial t}=p f_2(t)=p f_2^2 f_3$$

where p is a constant.

Thus we get

$$f_2=B\,e^{pt},\quad f_3=\frac{1}{B}\,e^{-pt}$$

Choosing $p=-u_0\lambda$ we ultimately get

$$\left.\begin{aligned}\rho(x,t)&=\rho_0 e^{-\lambda(x-u_0t)},\quad l^2(x,t)=l^2(x)\,e^{u_0\lambda t}\\ u(x,y,t)&=u(x,y)\,e^{-u_0\lambda t}\end{aligned}\right\} \qquad ..(13)$$

the constants B and $\frac{1}{B}$ have been supposed to be included in $u(x,y)$ and $l^2(x)$. These functions are still to be determined.

The equation (12) becomes

$$-\lambda u_0\, u(x,y) + u_0 \frac{\partial u\,(x,y)}{\partial x} = -2\, l^2\,(x) \frac{\partial u\,(x,y)}{\partial y} \cdot \frac{\partial^2 u(x,y)}{\partial y^2} \qquad ..(14)$$

Writing simply l and u for $l\,(x)$ and $u\,(x, y)$ respectively and assuming

where

$$\left.\begin{aligned} \frac{u}{u_0} &= \frac{f\,(\eta)}{\psi\,(x)} \\ \eta &= \frac{y}{l\,(x)} \end{aligned}\right\} \qquad ..(15)$$

we get

$$\frac{\partial u}{\partial x} = -u_0 \left\{ \frac{\eta f'\,(\eta)\, l'\,(x)}{l\,(x)\psi\,(x)} - \frac{f\,(\eta)\,\psi'\,(x)}{\psi^2\,(x)} \right\},$$

$$\frac{\partial u}{\partial y} = \frac{u_0 f'\,(\eta)}{\psi(x)\; l(x)},$$

$$\frac{\partial^2 u}{\partial y^2} = \frac{u_0 f''\,(\eta)}{\psi(x)\; l^2\,(x)}.$$

Substituting these values in (14), we get

$$\lambda f\,(\eta) + \frac{l'\,(x)}{l\,(x)}\, \eta f'\,(\eta) + \frac{\psi'(x)}{\psi\,(x)}\, f\,(\eta) = \frac{2 f'\,(\eta)\, f''\,(\eta)}{\psi(x)\; l\,(x)} \qquad ..(16)$$

where dashes denote differentiation with respect to the variables given in the brackets against them.

Equation (16) will be a function of η only if we put

$$\frac{l'(x)}{l(x)} = a_1\;, \quad \frac{\psi'(x)}{\psi(x)} = a_2, \quad \psi\,(x)\; l\,(x) = a_3$$

where a_1, a_2, a_3 are constants.

Integrating the first two equations of the last expression we get

$$l\,(x) = a\, e^{a_1 x}\;, \quad \psi\,(x) = b\, e^{a_2 x} \qquad ..(17)$$

Putting these values in the third rusult

$$ab\; e^{(a_1 + a_2)\,x} = a_3$$

which is possible only if

$$a_1 + a_2 = 0$$

i.e.,

$$a_1 = -a_2 = \tfrac{1}{2}\,\lambda \text{ (say)} \qquad ..(18)$$

Hence

$$\left.\begin{aligned} &l\,(x) = a\, e^{\frac{1}{2}\lambda x}\;, \quad \psi\,(x) = b\; e^{-\frac{1}{2}\lambda x} \\ &\eta = \frac{y}{a}\, e^{-\frac{1}{2}\lambda x}\;, \quad \frac{u\,(x,y)}{u_0} = \frac{f\,(\eta)}{b}\, e^{\frac{1}{2}\lambda x} \end{aligned}\right\} \qquad ..(19)$$

With these substitutions, equation (16) becomes

$$f\,(\eta) + \eta f'\,(\eta) = \frac{2}{ab\,\lambda} f'\,(\eta)\, f''\,(\eta) \qquad ..(20)$$

Choosing the arbitrary constants a and b in such a way that $\lambda=\frac{2}{ab}$, equation (20) becomes

$$f(\eta)+\eta f'(\eta)=f'(\eta)f''(\eta) \qquad ..(21)$$

This is an equation which is for steady motion. The solution of this (Goldstein[3]) is

$$f(\eta)=\frac{2}{9}\eta_0^3\left\{1-\left(\frac{\eta}{\eta_0}\right)^{\frac{3}{2}}\right\}^2 \qquad ..(22)$$

At the edge of the wake $\eta=\eta_0, y=y_0$ and $f=0$, so that from (19)

$$\eta=\frac{y}{a}\,e^{-\frac{1}{2}\lambda x} \text{ and } \eta_0=\frac{y_0}{a}\,e^{-\frac{1}{2}\lambda x}.$$

Therefore

$$f(\eta)=\frac{2}{9}\,\frac{y_0^3}{a^3}\,e^{-\frac{3}{2}\lambda x}\left\{1-\left(\frac{y}{y_0}\right)^{\frac{3}{2}}\right\}^2 \qquad ..(23)$$

Hence using (13), (19) and (22) and using the result $\lambda=\frac{2}{ab}$ we get

$$u(x,y,t)=\frac{\lambda}{9a^2}\,u_0y_0^3\exp.\left\{-\lambda(u_0t+x)\right\}\left\{1-\left(\frac{y}{y_0}\right)^{\frac{3}{2}}\right\}^2 \qquad ..(24)$$

ENERGY EQUATION

Energy Equation (5) is

$$\rho\,\frac{\partial i}{\partial x}+\rho u_0\,\frac{\partial i}{\partial x}=\frac{\partial}{\partial y}\left(\varepsilon\rho\frac{\partial i}{\partial y}\right)+\varepsilon\rho\left(\frac{\partial u}{\partial y}\right)^2$$

Substituting the value of ρ from (11) and cancelling the common factors in all terms we get

$$\frac{\partial i}{\partial t}+u_0\frac{\partial i}{\partial x}=\frac{\partial}{\partial y}\left(\varepsilon\,\frac{\partial i}{\partial y}\right)+\varepsilon\left(\frac{\partial u}{\partial y}\right)^2 \qquad ..(25)$$

Taking i as a function of u only

$$\frac{di}{du}\cdot\frac{\partial u}{\partial t}+u_0\frac{di}{du}\cdot\;\frac{\partial u}{dx}=\frac{\partial u}{\partial y}\cdot\;\frac{d}{du}\left(\varepsilon\frac{di}{du}\;\frac{\partial u}{\partial y}\right)+\varepsilon\left(\frac{\partial u}{\partial y}\right)^2 \qquad ..(26)$$

Using the value of $u_0\,\frac{\partial u}{\partial x}$ from (4) and noting that ρ is a function of x and t, (26) becomes

$$\frac{di}{du}\;\frac{\partial}{\partial y}\left(\varepsilon\frac{\partial u}{\partial y}\right)=\frac{\partial u}{\partial y}\;\frac{d}{du}\left(\varepsilon\frac{di}{du}\;\frac{\partial u}{\partial y}\right)+\varepsilon\left(\frac{\partial u}{\partial y}\right)^2$$

Writing $\tau=\varepsilon\,\frac{\partial u}{\partial y}$ and assuming λ as a function of u only, we get

$$\frac{di}{du}\cdot\;\frac{\partial\tau}{\partial y}=\frac{\partial u}{\partial y}\cdot\;\frac{d}{du}\left(\tau\frac{di}{du}\right)+\tau\;\frac{\partial u}{\partial y}$$

$$\frac{di}{du}\cdot\frac{\partial u}{\partial y}\cdot\frac{\partial\tau}{\partial u}=\frac{\partial u}{\partial y}\left\{\frac{\partial\tau}{\partial u}\cdot\frac{di}{du}+\tau\,\frac{d^2i}{du^2}\right\}+\tau\,\frac{\partial u}{\partial y}$$

Cancelling $\frac{\partial u}{\partial y}$ this expression is reduced to

$$\frac{d^2 i}{du^2}+1=0 \qquad ..(27)$$

Solution of (27) is

$$i=A'+B'\,u-\tfrac{1}{2}\,u^2$$

which gives

$$i_0-i=c\,(u_0-u)-\tfrac{1}{2}\,(u_0{}^2-u^2) \qquad ..(28)$$

Thus writing the value of $u\,(x, y, t)$ in (28) we get an expression for i.

ACKNOWLEDGEMENT

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11. Reference 3 page 582 Eq. (51).

SOME FRUIT PESTS OF KUMAON HILLS

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Under a scheme financed by U. P. Scientific Research Committee, Allahabad, a survey of the fruit pests of this region was carried out in the Department of Zoology, Th. D.S.B. Govt. College, Naini Tal.

The fruits which are exported from this region are apples, peaches, plums, and apricots. The main orchards are located at Ram Garh, Shyam Khet, Jelling estate (Bhowali), Chaubattia (Ranikhet), Jeolikot and Naini Tal.

The authors wish to express their gratefulness to the U. P. Scientific Research Committee, Allahabad for sanctioning the scheme and a contingent grant. They are thankful to Dr. D. D. Pant, D.Sc., Principal of the college for constant encouragement. They are also greatly indebted to the Entomologist, Hill Fruit Research Station, Chaubattia for providing all the facilities and allowing to study the fruit pests from their collection.

Order COLEOPTERA

Family MELOIDAE

Mylabris phalerta (Pallas)

This pest was collected in the months of July and August when it is to be found in abundance from the orchards located at Bhowali and Chaubattia. A few were also collected from Naini Tal. They damage the peach leaves, sometimes very seriously. This pest is being recorded for the first time from this region.

Family RUTELIDAE

Anomala polita Blanch.

These beetles are commonly observed during the months from June to September. They are leaf defoliators of apple, peach and pear. A number of these pests were collected from Ranikhet, Shyam Khet and Bhowali.

Anomala lineatopennis Blanch.

Dr. Beeson reported this pest first of all from Naini Tal District. We collected it from apple orchards of Ranikhet and Bhowali. They are seen in abundance in the month of June. This pest also like *Anomala polita* was seen to attack the leaves of the apple tree and defoliating them.

Anomala rufiventris Redt.

This pest was collected from the apple orchards of Chaubattia, Ranikhet and Bhowali. They are very common in the months of June and July. Mostly they feed on the apple leaves.

Anomala dimidiata Hope

These beetles were collected from different orchards of Ranikhet an d Shyam Khet. This pest is commonly observable in the months of July and August. Usually they are found feeding on the foliage and fruits of plum, peach and apple.

Adoretus bimarginatus. Arrow

This pest is very common in the months of July and August when they are found feeding on the apple leaves at Bhowali, Ranikhet and Jelling estate.

Adoretus versutus Harold

These beetles were collected from the different orchards of Ramgarh, Bhowali and Ranikhet. In the months of June and July they are seen to be feeding mostly on apple leaves, but a few were also collected when feeding on the apricot leaves.

Popillia complanata Newn.

This pest was collected from the orchards of Ramgarh, Ranikhet and a few from Naini Tal. During the months of June to August when it is to be found in abundance. They are very injurious to apple trees as both the fruits and leaves are eaten by them.

Popillia cyanea Hope

They are very abundant from June to August. Most of the specimens with us were collected from the apple orchards of Ramgarh, Chaubattia, Ranikhet, Shyam Khet, Jelling estate and Bhowali. This pest usually feeds on the apple fruits and sometimes the heavily infested fruits fall down in the premature condition.

Family SCARABAEIDAE

Catharascious molossus Linn.

This pest was collected from the apple orchards of Chaubattia, Ramgarh and Bhowali. These are commonly observed during the rainy season. Usually the apple fruits and leaves are damaged by their feeding activity. Prashad and Hora (1930) reported this pest first of all from Naini Tal District.

Xylotropes gideon Linn.

This pest was collected from Chaubattia, Ramgarh and Bhowali orchards. They are very injurious to the apple fruits during the months of July and August, the time of emergence of the beetles. The infested fruits drop down before maturation.

Protaetia neglecta Hope

This pest was collected from the orchards of Ramgarh, Bhowali, Chaubattia and a few from Naini Tal. During the months of July and August when they are to be seen in abundance the foliage and fruits of the apple trees are injured by their feeding activity.

Clinteria spilota Hope

These beetles were collected from the apple orchards of Ranikhet, Shyam Khet and Ramgarh. They emerge in the months of July-August and feed on the apple fruits and leaves. For the first time this species is being reported from this region.

Rhomborrhina glaberrima Westw.

This pest was collected from the orchards of Ramgarh and Chaubattia. Though they are very common throughout the rainy season but are much abundant in the month of July. Usually they feed on the apple leaves as well as on the fruits.

Torynorrhina opalina Hope

Very common almost throughout the rainy season. Collected from the orchards of Chaubattia, Ranikhet, Ramgarh and a few specimens from Naini Tal. Like many other pests belonging to this family they also are the defoliating beetles.

Family MELOLONTHIDAE

Brahmina corracea Hope

These beetles were collected from the orchards of Bhowali and Chaubattia. During the month of July when the pest is in abundance the foliage of apple and pear are severely damaged.

Brahmina crinicolis Burn.

This pest was collected from the orchards of Bhowali, Ramgarh and Ranikhet. Like the former species it is also leaf defoliator of apple and is commonly observed in the months of July and August.

Lachnosterna longipennis Bl.

This pest is very commonly seen throughout the rainy season in different orchards of Ramgarh, Chaubattia and Shyam Khet. The leaves of pear and apples are defoliated by their feeding activity.

Family CEREMBYCIDAE

Lophosternus hugelli Redt.

The pest "Apple-root borer of Kumaon" was collected in the months of July and August when it is to be found in abundance, from the orchards of Ranikhet, Ramgarh and Bhowali. The grub of this beetle bores into the roots of apple tree. It is such a serious pest of apple that sometimes the trees are rendered barren to bear the fruits. Though it is primarily harmful to apple but sometimes also attack pear, peach and apricot.

Family CHRYSOMELIDAE

Platypyria hystrix F.

Collected from the orchards of Ramgarh, Chaubattia, Shyam Khet and Jelling estate during the rainy season when it is found in abundance. Mostly they damage the pear trees by defoliating.

Order HEMIPTERA

Family APHIDIDAE

Eriosoma lanigerum Hausmann

The pest "Apple wooly-aphis" was collected from Chaubattia, Ranikhet, Ramgarh, Jelling estate and Naini Tal. They are abundant in summer on the trunk, branches and twigs of the apple trees as bluish white cottony masses. Though most injurious to roots but its injuries above the ground causes the formation of galls or swellings similar to the ones on the roots. Due to its injuries the capacity of fruiting is lowered.

Anuraphis helichrysi Kalt.

The pest "Peach leaf curling aphis" was collected from the orchards of Chaubattia, Ranikhet, Ramgarh, Bhowali and Naini Tal. They damage the peach leaves in March and April. Apart from the peach leaves they also injure the plum leaves and to a lesser extent apricot. This aphid sucks up the foliage sap resulting in the detortion and curling of the leaves.

Family COCCIDAE

Quadrapidiotus perniciosus Comstock

It is a tiny insect that sucks the sap from the stem, leaves and fruit of apple, pear and peach. It is common in this region and is most injurious to apple trees. These insects lower the vitality of the tree and may gradually kill it. It has been collected from Chaubattia, Ranikhet, Shyam Khet and Jelling estate.

Pseudaulacaspis pentagona Targioni

This pest which is commonly seen in the months of July and August has been collected from Chaubattia, Ranikhet and Ramgarh. A few were also collected from Naini Tal. Usually this pest is harmful to the twigs of peach trees. Due to heavy attack the trees get dry and sometimes fall down.

Aonidiella (*Aspidiotus*) *auranti* Maskell

The pest "Red scale of citrus" was collected from the citrus orchards of Jeolikot. In this region the attack is not very severe. The damaged citrus fruits bear red scales on the surface which render the fruit useless.

Family PENTATOMIDAE

Rhynchocoris humeralis Thumb.

The different stages of the pest "Citrus green bug" right from the nymph to adult were collected from the citrus orchards of Jeolikot. These bugs are abundantly found in the month of November. Small citrus fruits fall down prematurely due to the sucking of the sap by the pest.

Family ALEYRODIDAE

Dialeurodes citri Ashmead

The pest "White-fly" which is very common in the months of June and July was collected from the citrus orchards of Jeolikot. They attach themselves on the lower surface of the leaves. The "Crawlers" suck the sap from the leaves resulting in the stunted growth of the trees and poor development of the fruits.

Order DIPTERA

Famiy TRYPETIDAE

Dacus ferrugineus Fabr.

It is a major pest of almost every variety of fruit in this region including many wild varieties. It is a clear winged fly and the fruit is pierced with a long ovipositor. The appearance of the fruit is spoiled and the damaged fruits with countless maggots within become soft and rot. This pest has been collected from almost all the orchards in the Kumaon region.

Family FORMICIDAE

Oecophylla smargdina F.

Though the "Red ant" which was collected from citrus orchards of Jeolikot is practically harmless to fruits and trees but even then cause nuisance by building nests on trees and sewing the leaves together.

ORDER LEPIDOPTERA

Family PAPILIONIDAE.

Papilio demoleus Linn.

The "Lemon butterfly" which was collected from the citrus orchards of Jeolikot mostly injures the lime, orange and malta fruits. Its larvae feed on all the citrus fruits and leaves.

Family LYCAENIDAE

Deudorix epijarbus Moor.

The "Anar butterfly" which is abundantly seen in the months of July and August was collected from the citrus orchards located near Jeolikot. The larvae of the butterfly bore into the pomergranate fruits making tunnel from one side to the other. The infested fruits ultimately fall down.

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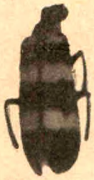
PLATE I



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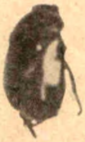

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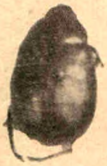

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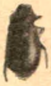

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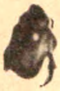

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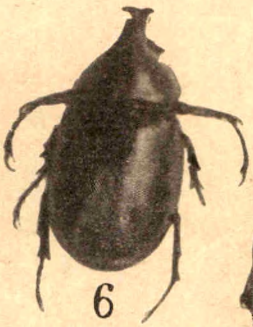

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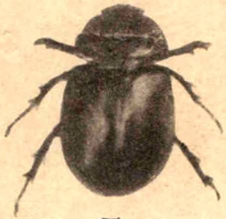

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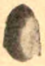

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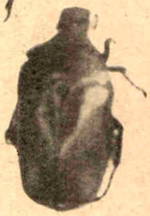

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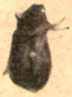

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Fig. 1. *Mylabris phalerta* Pallas
Fig. 2. *Anomala rufiventris* Redt.
Fig. 3. *Anomala dimidiata* Hope
Fig. 4. *Adoretus versutus*, Harold
Fig. 5. *Popillia complanata* Newn.
Fig. 6. *Xylotropes gideon* Linn. Male
Fig. 7. *Xylotropes gideon* Linn. Female
Fig. 8. *Clinteria spilota* Hope
Fig. 9. *Protaetia neglecta* Hope
Fig. 10. *Rhomborrhina glabe rrima* Westw.
Fig. 11. *Torynorrhina corracea* Hope
Fig. 12. *Brahmina corracea* Hope

PLATE II

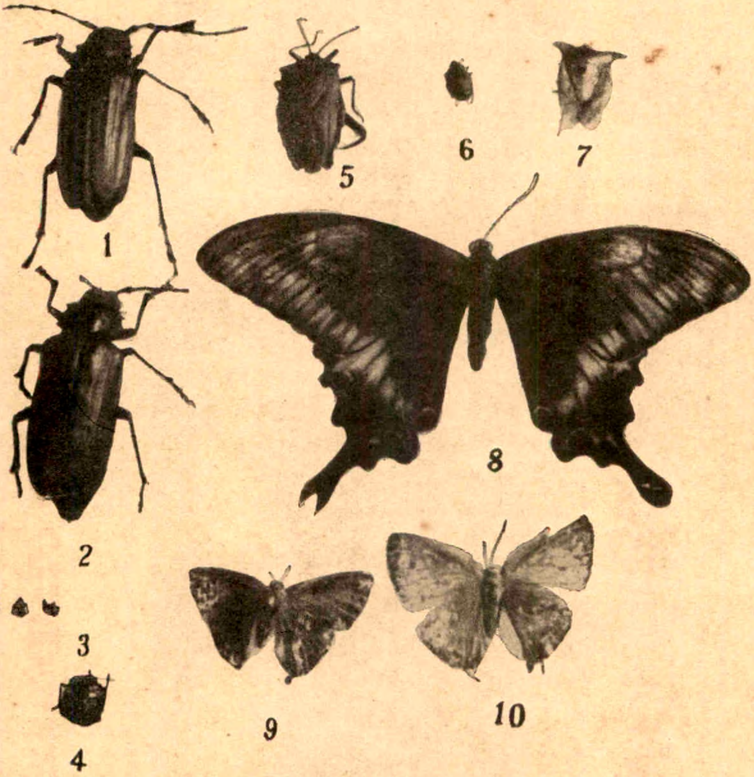

Fig. 1. *Lophosternus hugelli* Redt. Male
Fig. 2. *Lophosternus hugelli* Redt. Female
Fig. 3-7. Different stages of *Rhynchocoris humeralis* Thumb.
Fig. 8. *Papilio demoleus* Linn.
Fig. 9. *Deudorix epijarbus* Moor Male.
Fig. 10. *Deudorix epijarbus* Moor Female.

A LIST OF ALGAE FROM A FEW PADDY FIELDS OF KANPUR

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The algal flora of paddy fields has been studied by a number of workers in India, chiefly Banerji (1935), De (1939), Singh (1939) and Gupta (1957). The present communication deals with the algae observed in nature as well as in soil cultures of some paddy fields. The fields selected were also used after harvesting paddy for wheat cultivation during the Rabi season.

MATERIAL AND METHODS

The following soil samples were collected from the surface upto an inch in depth. Soil was removed by means of a sterilized scalpel and placed in previously sterilized bottles.

A & B—These samples were collected from two paddy fields of Kalianpur, at a distance of eight miles from Kanpur. Three collections were made *i.e.*, on 8th April, 8th June and 9th September 1962.

C, D & E—These samples were collected from three paddy fields of Agriculture College farm. Two collections were made. The first on 12th July and the second on 30th August 1962.

F, G & H—These samples were collected from three fields of Naramau, at a distance of about ten miles from Kanpur. The collection was made during the monsoon period on 9th September 1962.

Soil samples A, B & F were cultured separately in triplicate. 20 gms. of soil was weighed and placed in sterilized petri dishes and liquid Benecke's medium with potassium nitrate was added. The petri dishes were kept in artificial light. Mixed cultures were made from samples C, D & E and G & H. 5 gms. of soil was taken from each of the samples C, D & E, mixed thoroughly in a mortar and placed in the petri dishes. Similarly 10 gms. of soil was taken from each of the samples G & H, mixed as above and placed in petri dishes. The above soil cultures were also set up in triplicate.

Collections made from nature were examined the same day and the soil cultures were examined at frequent intervals.

A list of the algae observed is given below.

MYXOPHYCEAE

(1) *Chlorogloea fritschi* Mitra. Mitra, A. K. Two new algae from Indian soils, Ann. Bot. Lond., n.s., 14, 457, figs. 25-43, 1950; Gupta, The algal flora

of some paddy fields and its importance in soil economy. Part I. Jour. of Res. Vol. 4, No. I, p. 6, pl. I, fig. 3.

Diam. cells., 3-5·8μ.

Collected on 3-11-62 from fields C, D & E, and appeared in soil cultures of samples A & F.

(2) *Gloeocapsa atrata.* (Turp. Kütz), Desikachary, Cyanophyta, 1959, p. 116, pl. 24 fig. 8.

Diam. cell., 3-4·6μ; diam. cell., cum. vag., 4·6-6·4μ; diam. colony., 7·5-18·5μ.

In soil cultures of samples G-H. Fig. 1.

(3) *Aphanocapsa grevillei* (Hass) Rabenh. Desikachary, *op. cit.*, p. 134, pl. 21, fig. 9.

Diam. cell., 3·2-4·6μ.

In soil cultures of samples G-H. In nature, it was collected from the moist soil surface of field A, on 9-9-62.

(4) *Aphanothece pallida* (Kütz) Rabenh. Desikachary, *op. cit.*, p. 140, pl. 22, fig. 3.

Lat. cell., 3·2-6·2μ; long. cell., 4·8-10μ; lat. cell., cum. vag., 6·1-13μ; long. cell., cum. vag., 9·2-16·9μ.

In soil cultures of samples A & B. In nature, collected from field F on 3-11-62.

(5) *Chroococcus schizodermaticus* West. Desikachary, *op. cit.*, p. 103, pl. 26, fig. 17.

Diam. cell., 7-9·2μ; Diam. cell., cum. vag., 10·2-13·5μ.

Only once observed in a soil culture of sample A.

(6) *Phormidium foveolarum* (Mont) Gomont. Geitler, Kryptogamenflora, 1932, 999, fig. 636, c, d.; Gupta, *op. cit.*, p. 8, pl. 2, fig. 2.

Lat. trich., 1·4-2·1μ; long. cell., 0·8-2μ.

Growth profuse in soil cultures of samples A, B, C-D-E & G-H. In nature, collected from field C on 3rd and 25th November 1962.

(7) *Phormidium tenue* (Menegh) Gomont. Geitler, *op. cit.*, 1004, fig. 642 d, e; Gupta, *op. cit.*, p. 8, pl. 2, fig. 9.

Lat. trich., 0·8-2μ; long. cell., 1·5-4·6μ.

Growth profuse in soil cultures of samples A, B, C-D-E, F & G-H. In nature, collected from field A on 9-9-62, and field F on 3rd and 25th November 1962.

(8) *Phormidium bigranulatum* Gardner. Desikachary, *op. cit.*, p. 261.

Lat. trich., 0·8-1·2μ; long. cell., 2·3-3μ.

Differs from the type in having slightly broader and much shorter cells. In nature, collected from field A on 9-9-62.

(9) *Phormidium corium.* Desikachary, *op. cit.*, p. 269, pl. 44, figs. 10-11. forma. nova.

Thallus expanded, dark green; filaments long densly entangled; sheath thin, diffluent; trichomes blue green, 2·7-3·8μ broad; cells 2·2-3·8μ long; trichomes not constricted at the cross walls; ends slightly bent, attenuated, not capitate.

The form differs from the type in having narrower trichomes and slightly bent tips. Fig. 2. A, B, C.

Abundant in soil cultures of samples A, B, C-D-E, F & G-H.

(10) *Phormidium ambiguum* Gomont. Desikachary, *op. cit.*, p. 266, pl. 44, fig. 16 and pl. 45, figs. 5-8.

Lat. trich., 4·2-5·5μ; long. cell., 1·1-3μ.

Growth profuse in soil cultures of sample A.

(11) *Phormidium papyraceum* (Ag) Gomont. Desikachary, *op. cit.*, p. 271.

Lat. trich., 4·6-5·4μ; long. cell., 1·5-2·3μ.

Grew for a short time in a soil culture of sample B.

(12) *Phormidium autumnale* (Ag) Gomont. Desikachary, *op. cit.*, p. 276, pl. 44, fig. 24, 25.

Lat. trich., 4·6-6μ; long. cell., 1-3μ.

Growth profuse in soil cultures of samples B & G-H.

(13) *Phormidium uncinatum* (Ag) Gomont. Geitler, *op. cit.*, 1025, fig. 652, h,i; Desikachary, *op. cit.*, p. 276, pl. 43, fig. 1, 2 & pl. 45, fig. 9 & 10.

Lat. trich., 6-10·8μ; long. cell., 1·5-3·4μ.

The form differs from the type in having trichomes which are slightly broader and cells mostly shorter.

Abundant in soil cultures of samples A & B.

(14) *Oscillatoria curviceps* Parukutty. (Myxo-phyceae Travancore State, India, Proc. Indian Acad. Sci., II. 120, 1940).

Lat. trich., 6·1-9·2μ; long. cell., 0·8-1·7μ.

In nature, collected from the moist soil surface of field A on 9-9-62. Growth abundant.

(15) *Oscillatoria formosa* Bory ex Gomont. Desikachary, *op. cit.*, p. 232, pl. 40, fig. 15.

Lat. trich., 4·5-5μ; long. cell., 2·9-5·8μ.

In soil cultures of sample A.

(16) *Oscillatoria limosa* (Ag) ex Gomont. Desikachary, *op.cit.*, p. 206, pl. 42,fig. 2.

Lat. trich., 13-16·9μ; long. cell., 2·9-5·8μ.

In soil cultures of sample B.

(17) *Lyngbya nigra* C. Ag. ex Gomont. Desikachary, *op. cit.*, p. 317.
Lat. trich., 7·7-10·8μ; long. cell., 2-4·6μ.
Abundant in soil cultures of samples A, B & G-H.

(18) *Lyngbya martensiana* Menegh ex Gomont. Geitler, *op. cit.*, 1064, fig. 676; Gupta, *op. cit.*, p. 9, pl. 2, fig. 16.
Lat. trich., 7·1-12·1μ; long. cell., 2-4μ.
In soil cultures of samples A & G-H.

(19) *Lyngbya allorgei* Fremy. Desikachary, *op. cit.*, p. 313, pl. 54, fig. 6.
Lat. trich., 3·8-6·5μ; long. cell., 4·6-7μ.
In a soil culture of sample B.

(20) *Lyngbya semiplena* C. Ag. ex Gomont. Desikachary, *op. cit.*, p. 315, pl. 49, fig. 8.
Filaments forming a dull blue green expanded thallus; sheath upto 1·4μ, firm, not lamellated, trichomes not constricted at the cross walls, 5-6·1μ broad; cells 1·7-3·2μ long. End cell truncate and round, calyptra present.

In a soil culture of sample F. Fig. 3.

(21) *Microcoleus cthonoplastes* Thuret ex Gomont. Geitler, *op. cit.*, 1133, fig. 739; Gupta, op. cit., p. 10, pl. 3, fig. 20.

Lat. filament., 15·4-92·4μ; lat. trich., 2·2-4·2μ; long. cell., 4-10μ.

In nature, collected from field A 9-9-62. In soil cultures of sample A.

(22) *Plectonema puteale* (Kirchner) Hansgirg. Geitler, *op. cit.*, 691; Gupta, op. cit., p. 16, pl. 7, fig. 38.
Lat. filament., 3·8-5μ; lat. trich., 2-3μ; long. cell. 3-7·7μ.
In soil cultures of sample B.

(23) *Tolypothrix campylonemoides* Ghose. Desikachary, op. cit., p. 502, pl. 95, fig. 5.
Lat. trich., 4·8-8μ; long. cell., 3-7·5μ. het. lat., 6-8·7μ; het long., 4·3-8·2μ.
Growth profuse in a soil culture of sample A.

(24) *Aulosira prolifica* Bharadwaja. Bharadwaja, Contributions to our knowledge of Myxophyceae of India, Ann. Bot. Lond., 47, 131, fig. 5, 6, 1933.
Lat. trich., 4·6-5·8μ; long. cell., 9·2-18·5μ; cross sheath., upto 1·2μ; het. lat., 5·8-6·9μ; het. long., 10·8-17·7μ.

Collected from nature on the 28th September 1962. Found floating on the surface of water in a field near D.

(25) *Nostoc sp.*
Lat. trich., 3·2-5·4μ; long. cell., 4·3-10·5μ; het. lat., 4·8-7μ; het. long., 5-11μ.

Abundant in nature in field F attached to the surface of soil. Collected on the 3rd and 25th November 1962.

(26) *Nostoc sp.*
Lat. trich., 5-6μ; long. cell., 5-6·2μ; het. lat., 6-6·4μ; het. long., 7-7·5μ.

In soil cultures of samples C-D-E.

(27) *Nostoc punctiforme* (Kutz) Hariot. Geitler, *op. cit.*, 834, Gupta, *op. cit.*, p. 14, pl. 5, fig. 30, a-g.

Lat. trich., 2·8-4·8μ; long. cell., 2·4-4·8μ; het. lat., 5·4-5·8μ; het. long., 5·4-5·8μ; spores lat., 5-7·7μ; spores long., 5-8·4μ.

Observed once in a soil culture of samples C-D-E.

(28) *Anabaena sp.*
Lat. trich., 2·5-4·2μ; long. cell., 1·5-4·2μ; het. lat., 3·3-5·4μ; het. long., 3·5-5·4μ.
In soil cultures of samples F & G-H.

(29) *Anabaena sp.*
Lat. trich., 3·8-4μ; long. cell., 3·2-5μ; het. lat., 5·8-6·1μ; het. long. 6·1-7·7μ.

In nature, collected in vegetative condition from field A on 9-9-62.

(30) *Cylindrospermum stagnale.* f. *variabilis*, Prasad, B.N., Some Nostocaceae from Uttar Pradesh, J. Indian. Bot. Soc., 31 : 358, figs. 5-8, 1952.

Lat. cell., 3-4·6μ; long. cell., 3·8-7·7μ; het. lat., 4·6-6·1μ; het. long., 6·1-12·6μ; spore lat., 6·1-10·2μ; spore long., 12·3-21·5μ.

Abundant in nature, collected from the moist soil surface of field A, on the 9th September 1962.

CHLOROPHYCEAE

(31) *Chlorococcum humicolum.* Britton M.E. & Tiffany L.H., The Algae of the Illinois, p. 102, pl. 29, figs. 277, 278.
Diam. cells., 14·1-24·6μ.
Growth profuse in soil cultures of samples B, C-D-E, F & G-H.

(32) *Characium ambiguum.* Forti in de toni, Sylloge Algarum, Vol. 2, 1458, p. 623, Britton & Tiffany, *op. cit.*, p. 108, pl. 29, fig. 286.
Cell., 2·3-5·7 × 7·7-18·6μ.
Occurs as an epiphyte on *Pithophora* in soil cultures of samples C-D-E.

(33) *Pithophora varia.* Britton & Tiffany, *op. cit.*, p. 48, pl. 12, figs. 87, 88.
Vegetative cells., 45-47 × 255-885μ;
Akinetes., 75-135 × 105-248μ.

In nature, collected on 10th October 1962 from field E. In soil cultures of samples C-D-E.

(34) *Zygnema sp.*

In nature, collected from the water logged field D, on the 28th September 1962.

(35) *Spirogyra sp.*

In nature, collected from field D & E on 28-9-62.

(36) *Sirogonium sp.*

In nature, collected from field D on 28-9-62.

(37) *Chara sp.*

In nature, collected from fields C-D-E on 28-9-62.

ACKNOWLEDGEMENT

I take this opportunity to express my great indebtedness to Dr. A. B. Gupta for his valuable guidance and criticism throughout the course of this investigation.

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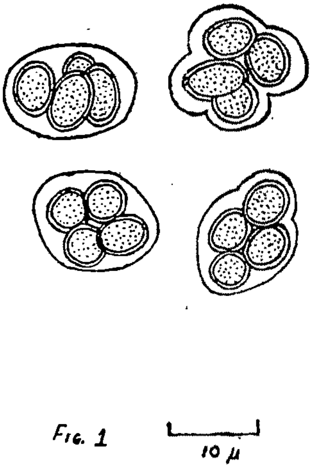

Fig. 1

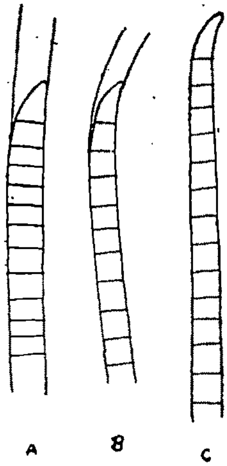

Fig. 2

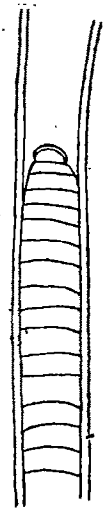

Fig. 3

1. *Gloeocapsa atrata* (Turp. Kütz) 2. *Phormidium corium*. forma. nova.

3. *Lyngbya semiplena* C. Ag. ex Gomont.

A REPLY TO COMMENTS ON MY PAPER ENTITLED "THE ORIGIN OF LIFE" BY SIDNEY W. FOX[1]

O. N. PERTI*
Professor of Chemistry, Th. D. S. B. Government College, Naini Tal, India.

Dr. Fox begins his comments by objecting to my statement as given on p. 15 of my paper,[2] namely : "If proteins arose by thermal polymerisation how are we going to account for the fact that almost all enzymes that have been studied so far are irreversibly inactivated by heat." Dr. Fox states that it is *well-known* that the rate of thermal denaturation of proteins is extra-ordinarily sensitive to contents of water. How *well-known* is this fact would be apparent by a quote from his own paper[3] published almost at the same time : "A second heresy concerns the belief that heat has generally been thought to be a reliable agent for denaturation of proteins. Not so generally known is the fact that this process is 'extraordinarily sensitive' to the amount of water present." Thus the case which he makes out stands condemned in his own words. Moreover, the general argument of Dr. Fox, that because under perfectly anhydrous laboratory conditions some proteins retain their enzymic activity upto a certain temperature and so all active proteins would have been formed initially by thermal copolymerisation of amino acids is not very convincing to us.[4]

The second para of his comments is meant to give the impression that for some undesirable motive I have deliberately omitted to describe at length his pet 'microspheres'. I may mention here that in his personal letter to me dated January 20, 1964 Dr. Fox in rather abusive language demanded an explanation for not describing at length his 'microspheres'. I quote from my reply to his personal letter : "....I am also sorry to note that I seem to have created a misunderstanding because I did not mention or dilate upon your work on 'microspheres'. Believe me, it was not done to belittle the importance of your well-known work. I did not also mention a few other type of 'particles' such as those of Butschli, Le duc or Kuckuck all of which are known to show some properties of a biological order." The fact is that at the time of writing the article I found some kinship in the behaviour of our units (termed by us *Jeewanu*, a Sanskrit word meaning particles of life) and the behaviour of coacervate droplets. It was natural for me to devote more space in my paper to what I considered to be relevent to the description of our units. My emphasis throughout was on properties of a biological order such as growth, multiplication, metabolic activity and so on and I was not much impressed by the behaviour of 'microspheres' so far as these properties are concerned. However, in my subsequent publications[5] I have described some features of 'microspheres' just to convince Dr. Fox that in my treatment of the subject no American *vs.*

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* Present address—M. L. N. Regional Engineering College, Allahabad, U. P., India.

Russian controversy is involved. I do not believe in introducing personal emotions in scientific estimations.

Next Dr. Fox mentions about some private communications to him from Dr. M. H. Briggs of U.K. I know nothing about these private communications. My statement on p. 16 of my paper[2] is not at all garbled. It refers to *my* correspondence with Dr. Briggs and has nothing to do with the correspondence of Dr. Fox with him. Dr. Fox's comments are confused and have no relevency to my statement referred to by him.

Further on Dr. Fox writes that my statement as given on p. 27 of my paper[2] is incorrect or categorically untrue. The statement in question is in reference to the nature of organised elements found in meteorites: "Fox[169] has suggested that they are organic polymers and sulphur in a super-cooled state sulful droplets." The reference 169 is : "S.Fox, cited by Claus, G., *et al*, *Ann. N. Y. Acad. Sci.*, (1963) under publication. The reference is to comments at Symposium on Extra-terrestrial Biochemistry and Biology, AAAS Meeting, Denver, 27th Dec., 1961." It may be mentioned here that when Dr. Fox objected to it in his private letter to me I wrote to him on May 2, 1964 as follows : "....I am extremely sorry that inadvertently I seem to have misquoted your opinion about the origin of 'organised elements'. I was led by the reference given in my paper. I also found that Dr. M. H. Briggs in his recent review about the subject has expressed a similar view about your opinion. I may add that Dr. G. Claus in his letter to me dated January 11, 1964 has written about your views as : "His idea was that these microstructures represent conglomerates of polymer macromolecules possibly proteinaceous in nature." I now request you to let me know your views in some detail so that I can correct myself." In his reply dated May 13, 1964 he did not mention any thing about this matter. So a reminder was sent by me on May 30, 1964. A letter from him dated June 8, 1964 informed me as follows : "My paper in Ann. N. Y. Acad. Sci. deals with morphological similarities; see p. 488, reprint enclosed. This is quotable as it is written. This does not say that I suggest that the meteoritic elements are organic polymers. Infact, I chose my words carefully not to make such a statement. My present statement does not mean, either, that I am stating that they are not organic polymers. I have many thoughts on what the elements might be. I intend to publish these after I have disciplined these thoughts sufficiently." The statement on p. 488 of his paper referred to by him is a single sentence which runs as : "They and derivatives are of interest also for their morphological similarity to some microfossils and to formed elements found in meteorites." Here 'They' refers to microspheres. As far as I am aware Dr. Fox has not yet published his 'disciplined' views about the nature of organised elements. I would also like to mention here that my interest in these microstructures was only by the way. I found that some aggregates of *Jeewanu* had a resemblence with photomicrographs of 'organized elements' as published under the editorship of M. H. Briggs and G. Mamikunian. About half-a-dozen photomicrographs of aggregates of our units were sent to M. H. Briggs and he was of the opinion that these looked remarkably like the type of structures found in carbonaceous chondrites. This fact was mentioned in the paper. Since then my interest in 'organized elements' has ceased and I have no wish to persue the matter further.

Next Dr. Fox gives "the outlines of the full true picture" of what transpired when Dr. K. Bahadur was working in his laboratory. Since the matter concerns Dr. K. Bahadur only I requested him to give full details and not mere outlines of the true picture. This he has done in his article entitled "About a few experiments on the preparation of *Jeewanu* from thermal peptides" published elsewhere in this Journal. I have no comments to add to it as I was not a witness to what transpired when Dr. K. Bahadur was working with Dr. Fox. On my part I would only add that I have never worked with thermal copolymers of amino acids of the type used by Dr. Fox in his experiments and I do not mention a single experiment involving these thermal copolymers in my paper.

I do not know which of the experiments described in my paper have been repeated by Dr. Fox. Since his statements are rather sweeping I wrote to him and to Dr. Young on June 2, 1965 enquiring as to which of the experiments described in my paper has been repeated by them and if so with what results. A reminder was sent to them on July 8, 1965. So far (July 31, 1965) I have heard neither from Dr. Fox nor from Dr. Young*. It is therefore apparent that Dr. Fox had something else in his mind other than the experiments described in my paper. This is a strange way of making comments on scientific communications. To me it is all the more surprising as some of the experiments described in my paper have been repeated, confirmed and extended in U. K.[6,7]

Scientific sagacity forces Dr. Fox to realize that even today not every body is impressed either by his thermal pathways or by his microspheres. He neither hurls abuses nor imputes motives to A. I. Oparin for ignoring his work in his latest book entitled "The Chemical Origin of life" (1964). In the review of this book Dr. Fox himself writes[8] : "The musicians contributing tones to a possible orchestration of the theory of the origin of life are simultaneously reading from different scores; at present much discordance can be heard." It is only where our work is concerned that Dr. Fox exhibits emotional imbalance. From the very beginning he has been opposing the publication of our results. In his letter dated May 16, 1963 to Dr. K. Bahadur, a copy of which was sent to me also, he talks of unrepeatability of certain experiments of K. Bahadur presumably dealing with his thermal copolymers of amino acids and at the same time considered publication of the results as "potentially a crime against all humanity". However, the experimental work dealing with production of *Jeewanu* by different methods has been now published in different Journals of the world[2,9,10,11,12] and the confirmation of this work in U. K. by M. H. Briggs[6,7] is under publication.

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* Since then a reply has been received to the effect that Dr. Fox's comments do not refer to experiments described in my paper.

Dr. Fox knows fully well that in the present state of our knowledge scientists are approaching the problem of the origin of life and related topics from different angles. Each is presenting his side of the picture and we have tried to present ours. Our picture is that of photochemical pathways employing aqueous medium and *via* units which we have termed *Jeewanu*. It is perfectly useless to impute motives or use abusive language while discussing relative merits or demerits of any scientific hypothesis for time and further experimentation and not mere comments can establish the superiority of one over the other.

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ABOUT A FEW EXPERIMENTS ON PREPARATION OF JEEWANU FROM THERMAL PEPTIDES

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Dr. S. W. Fox in his comments on the paper of Dr. O. N. Perti on "The Origin of Life", published in Agra University Journal of Research (Vol. XIII, Part I, 1964, pp. 139-140), mentions the fact of my being in his laboratory for sometime in 1962-63. Some of the remarks in his comments on my work in his laboratory need clarification.

First we take the problem of enzymic activity in his thermal peptides. Dr. Fox's arguments about the stability of enzymic activity against heat under anhydrous conditions is a well known fact in biochemistry. Working with papain, one of the most stable vegetable enzymes, we have observed that whereas papain is completely deactivated within a fraction of a minute at 100°C in presence of water, the enzyme shows considerable milk clotting property even when anhydrous papain is heated at 100°C for 4 to 5 minutes(1). However, Fox uses the stability of enzymes under anhydrous condition to suggest that enzymes will remain active even at the temperature at which he prepares his thermal peptides because he works above 100°C and no moisture will remain in the mixture. He usually prepares the thermal peptides by heating a mixture of natural amino acids at about 160°C in partial atmosphere of nitrogen for about 8 to 10 hours. This temperature can be decreased to below 100°C if phosphoric acid is used in the mixture but I am not sure what he does to keep this mixture anhydrous. As it is well known that formation of peptide linkage is accompanied by evolution of water, I am not clear as how he thinks that any of his mixtures will be free from water. May be he means liquid water is not present at least in mixtures which are heated above 100°C. So far as I see, the presence of even steam will denature protein molecules at high temperature resulting in deactivation of the enzymes.

However, this is not an argument suggesting that there is no enzymic activity in his thermal peptides. His thermal peptides may have some enzymic activity because I am of the opinion that many peptides particularly in presence of metallic ions behave as mild enzymes no matter what and how haphazard sequence of amino acids they may have. Those who are interested in this aspect are referred to Calvin's work on Evolution of Enzymes(2), and I think combination of metallic ions and organic molecules produced materials which had weak enzymic activity and these protoenzymes helped in the metabolic processes of the earliest cells or eobionts.

Dr. Fox claims that the peptides formed by heating the mixture of amino acids have some sort of sequence of amino acids in their chain. So these are protein like and he has named them as Proteinoids—thereby meaning protein like small molecules. This is why he emphasises the stability of enzymes against heat under anhydrous condition. I do not want to go into detail about it for I leave the readers to think for themselves the possibility of there being a sequence of amino acids in peptides which have been prepared by heating a mixture of amino acids to 160°C for 8 to 10 hours.

About Dr. Fox's experiments on enzymic activity in thermal peptides one thing needs mention. After heating the mixture he dialyses the fused mass for a few days at room temperature. When I reached his laboratory, I found many such mixtures being dialysed. I immediately suspected infection for a bacteriologist can easily imagine what will happen to a solution of protein, peptides or amino acids if kept for dialysis at room temperature for a few days. I examined the products with Petri dish culture method and found all the samples badly infected. I developed a technique for aseptic dialysis and told it to Dr. Fox. I wonder whether the enzymic activity about which he wrote were observed in these aseptically dialysed products or in his old septically dialysed materials for there are extra cellular enzymes in bacterial putrefaction and these might have been present in the dialysis bags.

The way Dr. Fox compares his cell-like structures to the organized elements in carbonaceous chondrites is of no interest to me. Our interest is solely in our particles. Unfortunately Dr. Fox seems to be under the impression that his microspheres and Jeewanu are the same. A further study of Jeewanu will clear this fallacy.

When I reached his laboratory he was working on microspheres. Many organic substances are soluble in hot water but sparingly soluble in cold water. There are some organic compounds which though have melting point far above the room temperature yet remain in liquid phase for some time when they separate out from a solution. Thermal peptides have these characteristics. So if one boils a little thermal peptide with water and cools, small spherical particles of thermal peptides separate out. These particles have been named as microspheres. Dr. Fox has a number of publications on microspheres. I did not work on these particles but on particles prepared from thermal peptide-molybdate complex and synthesised in specific chemical environment. This was just one of the series of experiments on the preparation of Jeewanu. The characteristics of Jeewanu has been described(3). I pointed out these to Dr. Fox several times when I was with him but he failed to note these because in his mind he always held that these are in no way different from his microspheres.

Microspheres coalesce after about 24 hours and form clumps at the bottom of the test tube. Microspheres are made of solid brittle material and if pressed these break radially into four pieces. Jeewanu retain their forms indefinitely. They are made of a semi-solid, honey-like material and are smashed to pulp on pressing. Moreover, Jeewanu grow in size, multiply by budding after they have reached the maturity size and have metabolic activity in the sense that the materials inside the Jeewanu are synthesised within their body from the environmental molecules entering into them and thus the chemical composition of these materials present in their body is different from the materials in the environment.

During the short life period of microspheres Dr. Fox was trying to induce whatever properties of living system possible in these microspheres. All his experiments on microspheres before I reached his laboratory were being done under septic conditions. I was shocked by the alchemic approach that was being given to the study of origin of life. I do not agree with Dr. Fox's views that anhydrous heat formed peptides in the pre-biological era in sufficient amounts as to act as starting material for the formation of protocells. We hold that peptides were formed in water which contained amino acids and inorganic catalysts, when these were exposed to the radiations available on the surface of the earth and sun-light played an important part in this process.

I further disagree with Dr. Fox that the proto-cells were formed by a process similar to the formation of microspheres and I believe that the molecular associations with the characteristics of living systems were formed because of certain inherent properties of the matter concerned. A complete account of ideas have been described in my paper, "Conversion of lifeless matter into living systems" published in Zentralbratt fur Bakteriology, 118, II, 671-694 (1964).

When I was in Dr. Fox's laboratory I read all what Dr. Fox gave me to read and I gave considerable thought to his views but I could not agree with quite a few of his ideas. However, both of us were in agreement that now we have reached a stage in our understanding when we could start the experiments on the formation of a system with characteristics of life. Our reasons for the same conclusion were different; Dr. Fox thinking that as his microspheres are spherical, cell-like, have boundary wall, are capable of absorption and show tendency of splitting, he may be able to find out a few chemicals "which may do the trick", and I thinking on the lines described in my paper mentioned above and by the conclusions of my photochemical experiments I had already performed, believed that I will be able to synthesise Jeewanu from Dr. Fox's material also and I told Dr. Fox about my experiments with citric acid mixtures which were later repeated and confirmed by Dr. M. H. Briggs(4).

I reached Dr. Fox's laboratory on 26th Nov. 1962 and after a few days I started the work on the formation of these molecular associations. On 31st Dec. 1962 I prepared these units and showed them to Dr. Fox who came to my flat on 31st evening to congratulate me for this work.

However, further developments were not very pleasant. I agreed that when the work is repeated it will be published under our joint names. It was further agreed upon that we will publish only the experimental part under our joint names and then give our views as. why the phenomenon happens, separately under our separate names. This is because we greatly differed in our understanding of the process.

I repeatedly requested Dr. Fox to find time for actual experimentation and repeat the work himself, but he was too busy in things other than experimentation and preferred to engage other persons to repeat the work. I was asked to write down the procedure in as much detail as possible and give it to him and I did so. Two scientists from California Dr. Richard S. Youngs and Cryil Ponnamperuma who were Dr. Fox's collaborators were visiting his laboratory. First I was told not to speak a word about these experiments to them. However, in the noon of the day they came to the laboratory, Dr. Fox said that I should tell the work to them and they were asked to repeat the experiments. A copy of the manuscript was sent to them and one copy of the manuscript was kept with Dr. Metz, the Head of the Zoology Department, Florida State University, Tallahassee, for custody. One research assistant of Dr. Fox was also given a copy of the manuscript for repetition.

This research assistant performed the experiments in a different way avoiding the exposure part of my experiments and did not get any result. I was asked to examine the experiments. I was annoyed to note that the experiments were not carried out as I had suggested. However, exposure was done and on repetition, as Dr. Fox told me, increase in the size and number of the units were observed. He, however, expressed the desire that we should wait till we hear from the Californian scientists and to this I agreed.

The experiments were perhaps never repeated in California as far as I am concerned. Whenever I asked about the progress and results of my experiments in California, I was given any one of the following answers (though not always in the same sequence)—the experiments have just been started, the experiments are half way and results will be known shortly and the experiments will be started in a few days. I wrote several letters to Dr. Youngs and Dr. Ponnamperuma but I did not hear a line from them about it. After about a year or so, Dr. Ponnamperuma wrote that he was very busy and did not perform the experiments.

However, a few days before my departure for Allahabad from Tallahassee Dr. Fox left Tallahassee and no body knew where he had gone. I was worried because only two days were left for my departure and I did not wish to leave the place without meeting him. However, Dr. Metz told me that Dr. Fox is in Dr. Young's laboratory in California and he will know the result of my experiments when he returns. Dr. Fox came next morning but said nothing about the experiments. I returned to India.

After coming to India, I wrote the papers. It is a series of three papers. One deals with the theoretical understanding of the problem as we visualise it with Dr. S. Ranganayki and myself as the authors. The second section deals with the preparation of Jeewanu with peptides photochemically prepared and in this Dr. O. N. Perti and his student, myself and my students are the authors. The third section concerns with the preparation of Jeewanu with thermal peptides in which Dr. S. W. Fox and myself were the authors as agreed upon. I sent a copy of the complete manuscript to Dr. Fox and informed him that I will like to publish the work in this form. On this Dr. Fox wrote a most objectionable and unpolite letter to me, and added that the work is not repeatable* and he did not want to associate his name with this paper. Meanwhile he wrote insinuating letters to Prof. N. R. Dhar, Dr. Balbhadra Prasad, the then Vice-Chancellor of my University, Dr. P. Maheshwari and God knows to whom else.

I, therefore, dropped his name from the third section of the paper. The paper was communicated to Vijnan Parishad Anusandhan Patrika for favour of publication. The paper was referred to Prof. J. P. S. Haldane who recommended its publication.

I would also like to make it clear that all the experiments which I performed in Dr. Fox's laboratory were done exclusively by me without the help of Dr. Fox or any of his research assistants except for a photographer who helped me in taking photomicrographs and all the experiments which I performed were initially different in approach and technique from what was ever used in Fox's laboratory for the study of his microspheres or for which even a record was kept in his unpublished work. I have left an account of the experiments that I performed in his laboratory written in my own hand writing with him for record.

Even then if Dr. Fox finds any thing which he thinks is his own, I can certainly put his name on that and announce that part as his (rather, I had already agreed to keep his name on the whole in joint authorship as already mentioned). But unfortunately he thinks that nothing is repeatable. So his name is not in the list of authors and certainly the responsibility of the result lies on me and I have willingly accepted it.

Dr. Fox claims that many of the processes I have described have already been observed by him in his microspheres. I describe growth, multiplication and metabolic activity as the necessary properties to be present in a system to be admitted into the category of living system. And it is emphasised that all the three properties must be present in the same system before one can call a system as a living one, for these properties in single or in twos can be observed in many inanimate objects. I agree that perhaps it will be possible to get living systems with fewer properties than these but in the absence of a perfect definition of a living system at this stage of our knowledge I have preferred to select a definition of living system which does not actually demark the border line between the living and lifeless but is more towards the living side so that there may not be a chance of falling back into the inanimate zone.

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* It is of interest to mention that in the contribution No. 050 of the Institute of Molecular Evolution, University of Miami, Florida, which was added by Grant Ns G—689 of NASA, Fox et. al. have given time-lapse photomicrographs of growth and multiplication. The details of the proceedures are not given and obviously these may be different from mine.

If Dr. Fox thinks that his microspheres are living, he can announce it and face the music. If he thinks his microspheres are not living but very much near living he may proceed on the lines he thinks proper and induce the remaining fraction of life in them and I have no comment to make.

So far as I see a thing is either living or lifeless. I do not agree with the idea that a thing is 90% living and 10% lifeless. If one cares to read my paper in Zentralblatt fur Bakteriology, **118,** II, 671-694 (1964) entitled "Conversion of lifeless matter into living system", he will know my process of thinking.

The statement of Dr. Fox that the results were not repeatable in his laboratory and in Dr. Richard's Youngs' laboratory in Ames Research Center, Mountain View, California, is also not intelligible to me. Dr. C. Ponnamparuma as mentioned above did not repeat the experiments. The letter requesting Dr. Youngs and Dr. Ponnamparuma to repeat the work was formally sent to them under joint signature of Dr. Fox and myself. I wrote several letters to Dr. Youngs asking for the results but he did not reply at all. I met him in Pasadena in the last week of Feb., 1963 and he told me that his repetition experiments are half way and he will communicate the result to me in the near future. It has not been done till this day. After coming to Allahabad once Dr. Fox himself wrote that Dr. Richards S. Youngs has observed double the increase in number of these active units but Dr. Youngs thinks that it is because of the shaking of the mixture. We asked him to repeat the experiments exactly as suggested and report the results and not his opinion as why the things he is observing are happening. That needed lots of theoretical considerations and we had agreed not to say a word about them in the manuscript which was sent to Dr. Youngs. Growth and multiplication has been observed in time lapse photomicrographs of Jeewanu made of quite different materials than we are discussing here and any body can see that what to say of shaking even no movement is permissible in such experiments. Yet these particles give out buds which grow bigger with time.

The details of the experiments have been published and any body can repeat the work himself and know the truth. Dr. M. H. Briggs repeated quite a number of our experiments independently in his laboratory. In the beginning Dr. Briggs was skeptical about our work on the formation of peptides in aqueous solution. On 17th March, 1963 he wrote to me from Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, "Your method for synthesizing peptides by light seems to me the most important advance in this field for many years and I shall appreciate a full account of your experimental method so that I can attempt to repeat the work".

The details of the experiments were sent to him and on 12th June, 1963 he wrote to me :

"You will be pleased to hear that we have made some preliminary experiments on the photo-synthesis of peptides from amino acids.

"We tried several solutions simultaneously. A solution containing tyrosine showed the most obvious changes, probably I suspect, due to quinone formation and subsequent polymerisation. We exposed all the solutions for about three hundred hours to artificial light and all showed some peptide formation."

On 29th April, 1964, Dr. M. H. Briggs sent me a copy of his paper which he presented in the British Interplanetary Society in response to the invitation of the Society to him to give a paper on this subject.

In the introduction of this paper Dr. Briggs writes(4) "Several authors [see review of Oparin (5)] have conducted experiments to duplicate the morphology of cells by interaction of simple inorganic and organic mixtures. While there is no doubt that the products obtained by many of these workers do bear a morphological resemblance to living cells this is the only feature in common, in that the products formed are dissimilar in chemical composition, are metabolically inert, do not grow or reproduce etc. Moreover most of the artefacts are produced from substances and under conditions that were probably quite absent from the primitive Earth. The only interesting products are those of Fox(6) who has shown that thermally synthesised proteinoids produce microsphere in water.

"However, more recently Bahadur(4) and Perti(7) have described the formation of a series of cell-like microstructures (named by them 'Jeewanu', a sanskrit word for 'Particles of life') by the action of light and U.V. light on sterilised solution containing citric acid and colloidal salts of molybdenum and iron. *It is the purpose of this paper to report a confirmation and extension of this work*".

Concluding his paper Dr. Briggs writes, "while the definition of 'life' and 'living' are difficult problems, it can be said that these microscopic objects satisfy many of the criteria of living cells. It seems entirely probable that objects similar to those observed in the present experiments were formed in abundance in oceans of the primitive Earth and were the immediate precursors of cellular life".

Briggs certainly confined his experiments to our original photochemical work only which we had been doing in India and they have nothing to do with what I did in Dr. Fox's laboratory. In the fourth International Congress on Photobiology held at Oxford in July, 1964 Dr. Briggs presented the confirmation of another series of our experiments in almost similar words(8). As I wrote earlier we think light played very important role in the process of formation of the materials which made the earliest living systems and also in the formation of molecular associations with characteristics of living system.

Dr. Fox organised an International Conference on Abiogenesis in Nov. 1963 at Tallahassee. Dr. J. B. S. Haldane was invited to attend. After returning from this Conference and being operated in England for his cancer, when Prof. Haldane came to India he wrote a letter (No. 64/0019) to me on 9th April, 1964. A few lines of the letter are important. He wrote :

"I was at Tallahassee early in November. I was sorry that you were not there, as your Jeewanu are in some respects more life-like than his microspheres. He struck me as a man who could be rather difficult if one did not conform with his desires."

Abiogenesis, biopoesis, eobiogenesis and even neobiogenesis are highly specialised branches of science and the dogmatic views and emotional approach of the scientists can do immense harm to further research in these disciplines.

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SENSORY CANALS IN THE HEAD OF *SILONIA SILONDIA* (HAM.)

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INTRODUCTION

Curiously enough, with the exception of very few Indian species *e.g.*, *Notopterus chitala* (Omarkhan, 1949), *Ophicephalus punctatus*, *Heteropneustes fossili* and *Wallago attu* (Kapoor, 1959, 60, 61) and *Mystus seenghala* (Khandelwal and Rastogi, in press), the other species have been neglected in this respect. The purpose of the present paper is to give an account of the sensory canals in the head bones in one of the common available siluroid, *Silonia silondia* (Ham.).

MATERIALS AND METHODS

Adult specimens of *Silonia* were procured from the local fish market at Muzaffarnagar. The course of the sensory canals have been studied in the dried skulls and in disarticulated bones by inserting an animal hair in the canals and by injecting Indian Ink through the pores. Cleared alizarin preparations were made for the study of the various bones associated with the sensory canals.

OBSERVATIONS (Figs. 1, 2)

Supraorbital Canal (soc)—The *supraorbital canal* is enclosed throughout its length in the nasal (na) and frontal (fr) bones.

A pore placed at the anterior end of the nasal bone leads into the supraorbital canal, which runs inward and backward throughout the length of the nasal bone. The main canal passes out of the nasal at the posterior end and enters the frontal bone. The canal runs inward and backward for some distance through the frontal and then gives off a forwardly directed branch at its outer margin which opens to the outside by a pore (s2). Subsequently, the main canal runs further backward for some distance through the frontal, and opens to the outside at its inner margin by a pore (s3). This pore is situated in the mid-dorsal line, and just opposite to the corresponding pore of its counter part on the other side of the head. From this point the canal again runs backward and outward up to the posterior extremity of the frontal and leaves the bone to join the infraorbital canal (ioc) in the sphenotic region. Close to its junction with the infraorbital canal, the supraorbital canal gives off a forwardly directed branch enclosed within the frontal bone.

Infraorbital Canal (ioc)—The *infraorbital canal* is enclosed in the lachrymal, preorbital, two suborbitals, postorbital and sphenotic bones.

A pore (i1) placed at the anterior end of the lachrymal leads into the infraorbital canal which runs backward throughout the length of the lachrymal, preorbital, suborbitals and the postorbital. In the bones of the suborbital series this canal, neither gives any branch nor opens to the outside by any pore. As the canal passes out from the postorbital bone, it opens to the out side by a second pore (i2). From this point the canal enters into the sphenotic bone and runs backward up to its posterior margin. Finally it joins the supraorbital canal.

Temporal Canal (tc)—The *temporal canal* is enclosed in the pterotic, supratemporal and posttemporal bones.

The supraorbital and infraorbital canals join each other in the region of the sphenotic and from here the canal after running for a very short distance passes into the pterotic bone. The canal passes from the sphenotic to the pterotic bone without opening to the out side. The temporal canal after running nearly half way through the pterotic, opens to the out side by a pore (t1) placed on a small tube, which meets with the preopercular canal. The canal continues its course further backward enclosed within the outer margin of the pterotic throughout its length and then passes in the supratemporal bone without opening to the out side. The canal is finally conducted into the posttemporal bone and at the junction the canal opens to the outside by two separate pores (t2-3). From here the canal passes into the lateral line canal of the trunk.

Mandibular Canal (mc)—The *mandibular canal* is enclosed in the dentary and the angular bones.

A pore placed dorsally near the tip of the dentary leads into the mandibular canal (mc) and runs backward through the entire length of the bone. The canal opens through this bone to the outside by eight small pores (m1-7 and y). The mandibular canal first of all runs through the middle of the bone but near the suture of the dentary and angular it becomes ventral. The canal from the dentary is conducted into the angular bone and runs throughout its length. It opens to the out side at the posterior end of the angular. Coming out of the angular, the mandibular canal joins the ventral end of the preopercular canal (pc) and the junction between the two is marked by a pore (y).

Preopercular Canal (pc)—The *preopercular canal* is enclosed in the preopercular bone.

From its junction with the mandibular canal, the preopercular canal (pc) traverses through the entire preopercular bone. The canal after running for a short distance opens to the outs side by a pore (p1) situated at the end of the forwardly directed tube. The canal further runs backward and in the middle of the bone towards the outer margin it gives off two small branches which open to the out side by separate pores (p2-3). From this point the canal is conducted backward and runs upto the dorsal end of the preopercular where it finally opens to the out side by a pore. Here the canal meets the temporal canal (tc) nearly in the middle of the pterotic bone.

DISCUSSION

The course of the sensory canals in the head of *Silonia silondia* shows great similarity with a number of siluroids described earlier, but shows few variations when studied in detail.

The supraorbital canal in the nasal bone does not show any branch or pore unlike other siluroids described. A small tube arising from the main canal in the nasal bone has been described in *Chaetostomus* (Pollard, 1892), *Amiurus* (Collinge, 1895), *Heteropneustes* and *Wallago* (Kapoor, 1960, 61) and *Mystus* (Khandelwal and Rastogi, in press).

A commissural connection between the supraorbital canals of the two sides in the region of the frontal bone has been described in *Chaetostomus* (Pollard, 1892) and *Clarias magur* (Collinge, 1895). The latter also described an imperfectly developed frontal commissure in *Pimelodus*. The condition in *Silonia* is like *Wallago* and *Heteropneustes* (Kapoor, 1960, 61) and *Mystus* (Khandelwal and Rastogi, in press) where the supraorbital canal opens to the outside at its inner margin by a pore situated close to the mid-dorsal line, and just opposite the corresponding pore of its counter part on the other side of the head.

There is no posterior prolongation of the supraorbital canal in *Silonia* but a forwardly directed tube has been observed in the frontal bone. The posterior continuation of the supraorbital canal as the anterior pit line of *Amia* (Allis, 1889) has been described in a number of siluroids by nearly all the authors referred to above.

The infraorbital canal in *Silonia* is enclosed in the, orbital series and the sphenotic bones. The same course has been described in *Amiurus nebulosus* (Allis, 1904), *Wallago attu,* and *Heteropneustes fossilis* (Kapoor, 1960, 61) and *Mystus seenghala* (Khandelwal and Rastogi, in press). The canal in the sphenotic is enclosed in the sphenotic bone like *Amiurus* (Allis, 1904). Kapoor (1960) in *Wallago* reports that the infraorbital canal in the sphenotic bone lies in a gutter covered over by the skin only.

All available description of the preopercular and mandibular canals in the siluroids broadly conform with our observations in *Silonia* except *Chaetostomus* (Pollard, 1892) and *Clarias* (Collinge, 1895) where a small ventral portion of the preopercular canal is also enclosed in the inter-operculam or the continuation of the mandibular canals of the two sides in *Clarias* as described by Collinge (1895).

The preopercular canal opens in the temporal canal in the region of the pterotic like other fishes and confirm the Lakander's statement that "as a rule the preopercular canal opens in the temporal canal", though his statement is based on the observation of very small siluroid fishes. Kapoor (1960) in a specimen of 33 mm of *Wallago* found the preopercular canal independent of the temporal canal and in adult fishes he found the two canal joined in the pterotic region.

The temporal canal in *Silonia* like other siluroids runs backward through the sphenotic, pterotic and posttemporal bones, and in the region of the pterotic it joins with the preopercular canal. A supratemporal cross-commissural canal is wanting in *Silonia* although it has been recorded in *Amiurus catus* by Wright (1884) and Collinge (1895).

SUMMARY

1. There is no pore or branch in the supraorbital canal in the region of the nasal.
2. There is no posterior prolongation of the supraorbital canal comparable to the pit-line of *Amia.*
3. The infraorbital canal lies inside the sphenotic behind the eye.
4. The supraorbital and the infraorbital canals join each other behind the eye.
5. The mandibular canal is continuous with the preopercular canal and the latter communicates with the temporal canal in the region of the pterotic.
6. The frontal and supratemporal commissures are missing.

ACKNOWLEDGEMENT

The present work has been carried out in the Zoological Research Laboratory of D. A. V. College, Muzaffarnagar and the authors wish to express their gratefulness to Dr. V. P. Agrawal, Head of the Zoology Department for giving necessary research facilities.

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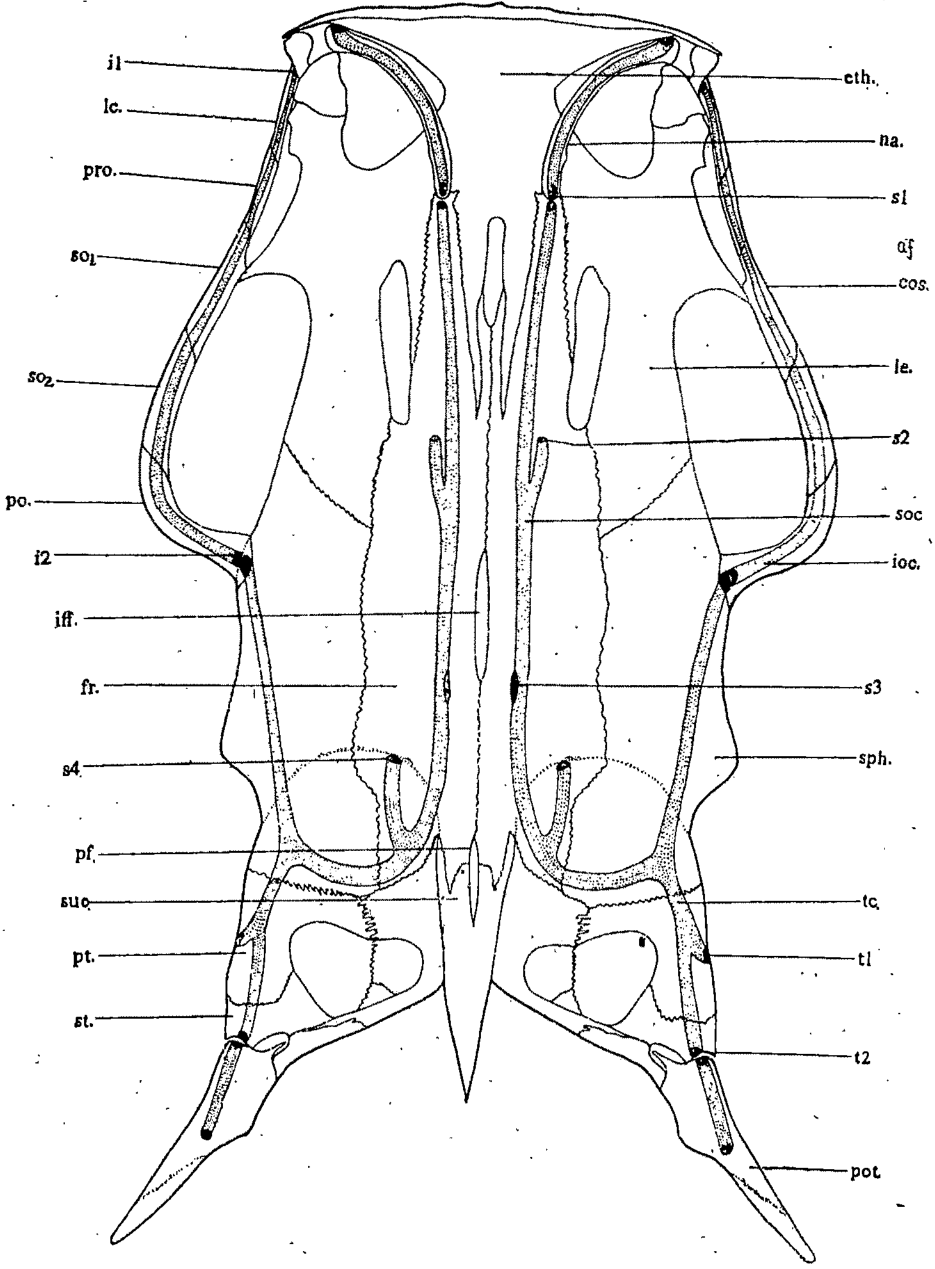
ABBREVIATIONS

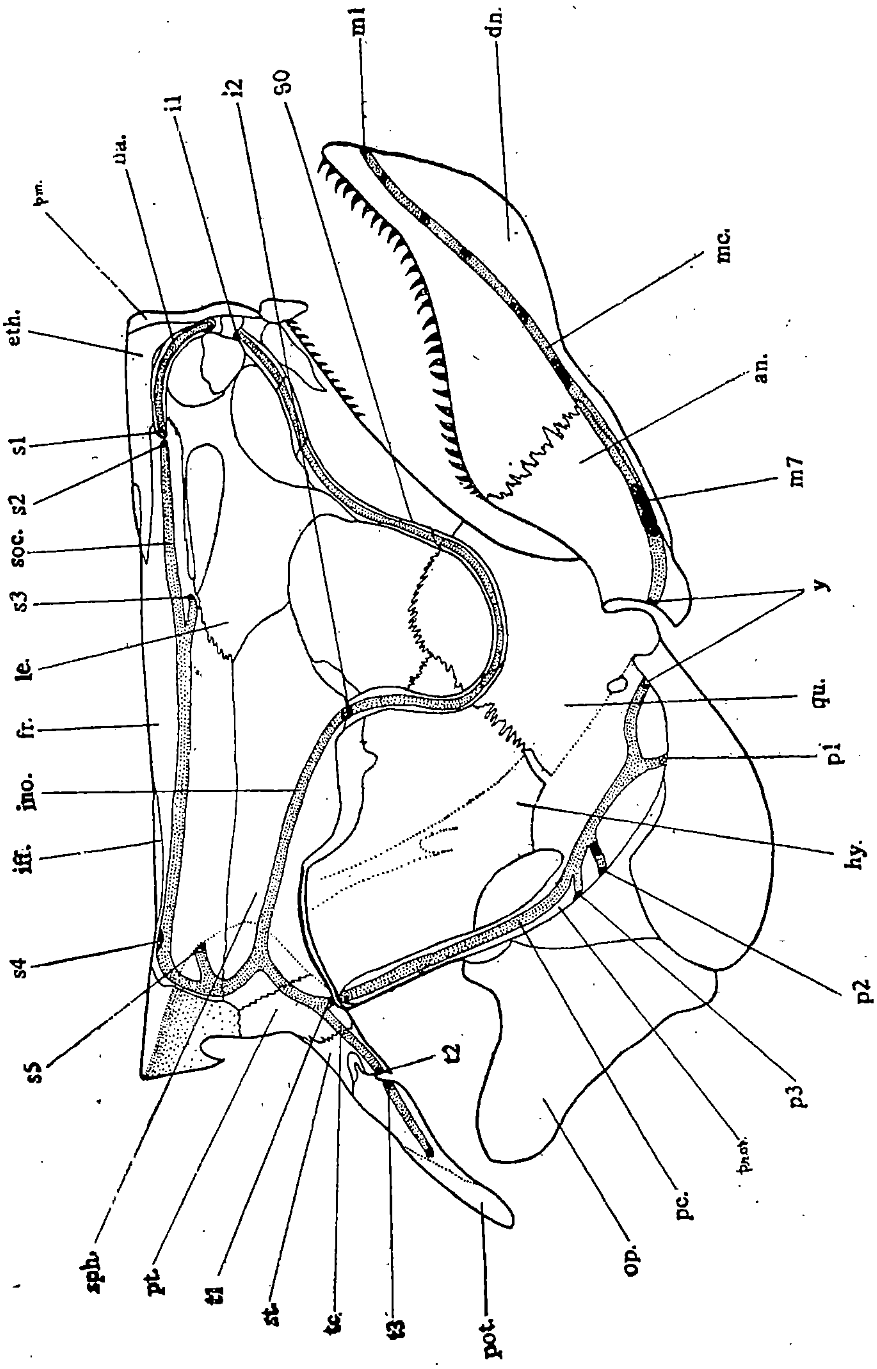
af., anterior fenestra; an., angular; dn., dentary; eth., ethmoid; fr., frontal; hy., hyomandibular; i 1-2., pores of the infraorbital canal; iff;., interfrontal fenestra; ioc., infraorbital canal; lc., lachrymal; le., lateral ethmoid; ml-7., pores of the mandibular canal; mc., mandibular canal; na., nasal; op., opercular; pl-3., pores of the preopercular canal; pc., preopercular canal; pf., posterior fenestra; pm., premaxilla; po., postorbital; pot., posttemporal; pro., preorbital; prop., preopercular; pt., pterotic; qu., quadrate; sl-5., pores of the supraorbital canal; sl-5., suborbitals; soc., supraorbital canal; sph., sphenotic; st., supratemporal; suo., supraoccipital; tl-3., pores of the temporal canal; tc., temporal canal; y., pore at the junction of the preopercular and mandibular canal.

Fig. 1



Dorsal view of the skull of *Silonia silondia* showing supraorbital, temporal and infra-orbital canals.

Fig. 2.



Lateral view of *Silonia silondia* showing all the sensory canals.

SENSORY CANALS AND RELATED BONES OF THE HEAD IN *RHINOMUGIL CORSULA* (HAM.)

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Introduction

The order Mugiliformes constitutes one of those orders of fishes in which the study of the sensory canals has been completely overlooked so far. The following account forms a part of the investigation in *Rhinomugil corsula* (Ham.) which exposes some facts relating to the course of the sensory canals.

The early reference concerning the lateral line system in fishes are provided by Sagemehl (1891), Pollard (1892), Collinge (1895), Herrick (1901) and Allis (1904). Friedrich-Freksa (1930), Lekander (1949) and Kapoor (1959, 60, 61) in later years, have made useful contributions in the field.

Material and Technique

The course of the sensory canals in the head has been studied in dried skulls and in disarticulated bones by inserting an animal hair in the canals and by giving injections of Indian Ink through the pores. The arrangement of the dermal bones have been made from cleared alizarin and dried preparations of the skull of the adult fish.

Observations

(Figs. 1, 2)

The supraorbital canal and related bones—The supraorbital canal is enclosed in the nasal and frontal bones.

The *nasals* (na) are a pair of small more or less triangular bones situated at the anterior end of the skull. The apex of the triangle points forward and is suturally connected with its fellow of the opposite side along the mid dorsal line. Behind this attachment a wide fontanelle separates the two nasals for the rest of their length. Posteriorly each nasal is overlapped partially by the frontal of its own side. The posterior end of each nasal articulates with the lateral ethmoid (le).

The *frontals* (fr) are a pair of large flat bones and are suturally connected with each other in the mid dorsal line. Posteriorly the two frontals are separated from each other by intervening supra-occipital (suo) bone. The lateral margin of each frontal is produced into a small process in the middle which articulates with the postorbital (po) bone. Each frontal articulates anteriorly with the nasal and lateral ethmoid, posteriorly with the supraoccipital and parietal (pa) and ventrally with the sphenotic.

The *supraorbital Canal* (soc) starts with a pore placed at the dorsal middle portion of the nasal. It runs backward through the entire length of the nasal and opens posteriorly near the frontal through a second pore. The canal is then conducted in the frontal bone into which it enters through an another pore situated at the anterior end of the bone. After running for a short distance the canal opens to the out side through a fourth pore (s4). From here the canal runs backward through half of the frontal and then curves outward, passing out of the bone to join the infraorbital canal (ioc). At this junction of the supra- and infra-orbital canals the former again opens to the outside through a fifth pore (s5). The canal further runs back from this junction in the frontal bone, which is described as a part of the infraorbital canal.

The infraorbital canal and related bones—The *infraorbital canal* is enclosed in the three pieces of orbital ring and in the frontal.

The three pieces of the orbital ring are placed round the orbit one behind the other. The preorbital (pro) articulates with the ventral border of the nasal and lateral ethmoid anteriorly. The postorbital articulates with the process of frontal posteriorly.

The infraorbital canal (ioc) is enclosed in all the three pieces of the orbitals and in the frontal bone. The canal starts with a pore (i1) placed at the anterior end of the preorbital and runs through it. The canal in this bone opens to the outside by a pore (i2) borne on a forwardly directed tube. The canal is conducted back into the suborbital and opens to the outside by third pore (i3) which is situated near the junction of the suborbital and postorbital. The canal after passing through the postorbital joins supraorbital canal in the frontal bone. The junction of the two canals is marked by a pore. After joining the supraorbital canal the infraorbital canal curves downward in the frontal bone behind the eye. It runs through the outer margin of the frontal to join the temporal canal. Before joining the temporal canal the infraorbital canal opens to the outside through a pore.

The temporal canal and related bones—The temporal canal is enclosed in the pterotic and in a extradermal bone.

The *pterotic* (pt) is an irregular bone on the posterolateral side of the skull. It articulates anteriorly with the frontal, anteromesially with the parietal (pa) and posteroventrally with the epiotic. Posteriorly it is connected with the extrascapular (es) bone.

The dorsal surface of the pterotic is overlaid by an extra dermal bone (do) which encloses the temporal canal. The extra dermal bone extends posteriorly upto the extrascapular bone.

The *temporal canal* (tc) starts with a pore (t1) placed at the anterior end of the pterotic, where it meets the infraorbital canal. It runs for a short distance in the pterotic bone along the lateral margin and opens to the outside by a pore (z). Here the canal joins the preopercular canal (pc). From this pore the main canal runs further back where it enters in the extra dermal bone placed on the dorsal surface of the pterotic. The temporal canal gives off a small branch mesially in the middle of the extra dermal bone which opens to the outside through a pore. The main canal is conducted back in the extra dermal bone upto the posterior end where it again opens to the outside to meet the lateral-line canal.

The mandibular canal and related bones—The *mandibular canal* is enclosed in the dentary and angular bones.

The two *dentaries* (dn) are suturally connected with each other at their anterior end. Each dentary is curved bifid bone interlocking posteriorly with the anterior end of the angular.

The *angular* (an) is more or less a triangular bone of which the apex fits into the posterior groove of the dentary. The posterior edge of the bone bears a socket for the articulation with the quadrate.

The mandibular canal (mc) starts with a pore placed ventrally near the tip of the dentary. The canal runs through the entire length of the dentary and the angular bone. Along its entire course, the mandibular canal opens through the bones to the outside by five pores. The first four pores are located in the region of the dentary, and the fifth pore (m5) at the point where the canal passes from the dentary to the angular. Passing out from the posterior end of the angular, the mandibular canal joins the ventral end of the preopercular canal and the junction between the two is marked by a pore (y).

The preopercular canal and related bones—The *preopercular canal* is enclosed in the preopercular bone.

The preopercular (prop.) is a crescent-shaped bone with concave dorsal and convex ventral edges. Anteriorly it articulates with the quadrate (qu) while the posterior end fits in between the hyomandibular (hy) and opercular (op) bones. Dorsally it articulates with the symplectic while ventrally it overlaps the interopercular.

The preopercular canal (pc) starts with a pore (y) situated at the ventral end of the preopercular. The canal runs backward along the entire length of the preopercular and finally passes out of it to join the temporal canal. The junction between the preopercular canal and the temporal canal is marked by a pore (z). Throughout its length, the preopercular canal opens to the outside by a number of pores, the first three pores being borne on large tubes arising from the main canal. Besides these there are a number of pores borne on very small tubes arising from the main canal. The canal in between the preopercular and the pterotic bone lies in the dermis.

SUMMARY

The arrangement of the sensory canals on the head of *Rhinomugil corsula* fits fairly well in the generalized plan of these canals in Teleostean fishes, except for a few deviations. The supraorbital canal does not show any posterior prolongation. The supraorbital canal and infraorbital canal join each other behind the eye and the infraorbital canal is also enclosed in the frontal bone. The mandibular canal is continuous with the preopercular and the latter communicates with the temporal canal in the pterotic bone running in the dermis between the pterotic and preopercular. The frontal- and the supratemporal commissures are missing. The temporal canal, besides enclosed in the anterior portion of the pterotic bone, also runs embedded in an extradermal bone, which lies over the posterior half of the pterotic and beyond it.

ACKNOWLEDGEMENT

The present work has been carried out in the Zoological Research Laboratory of D. A. V. College, Muzaffarnagar and the authors wish to express their gratefulness to Dr. V.P. Agarwal, Head of the Zoology Department for giving necessary research facilities.

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ABBREVIATIONS

an	angular
do	dermal ossicle
es	extrascapular
f	fontanelle
fr	frontal
i 1-3	pores of the infraorbital canal
io	infraorbital canal
le	lateral ethmoid

m1-5	pores of the mandibular canal
max	maxilla
mc	mandibular canal
na	nasal
op	opercular
p1-7	pores of the preopercular canal
pa	parietal
pc	preopercular canal
pmx	premaxilla
po	postorbital
pot	posttemporal
pro	preorbital
prop	preopercle
s1-5	pores of the supraorbital canal
so	suborbital
soc	supraorbiatl canal
sph	sphenotic
suo	supraoccipital
t1-4	pores of the temporal canal
tc	temporal canal
y	pore at the junction of the preopercular and mandibular canals
z	pore at the junction of the preopercular and temporal canals

RHINO MUGIL CORSULA (HAM.)

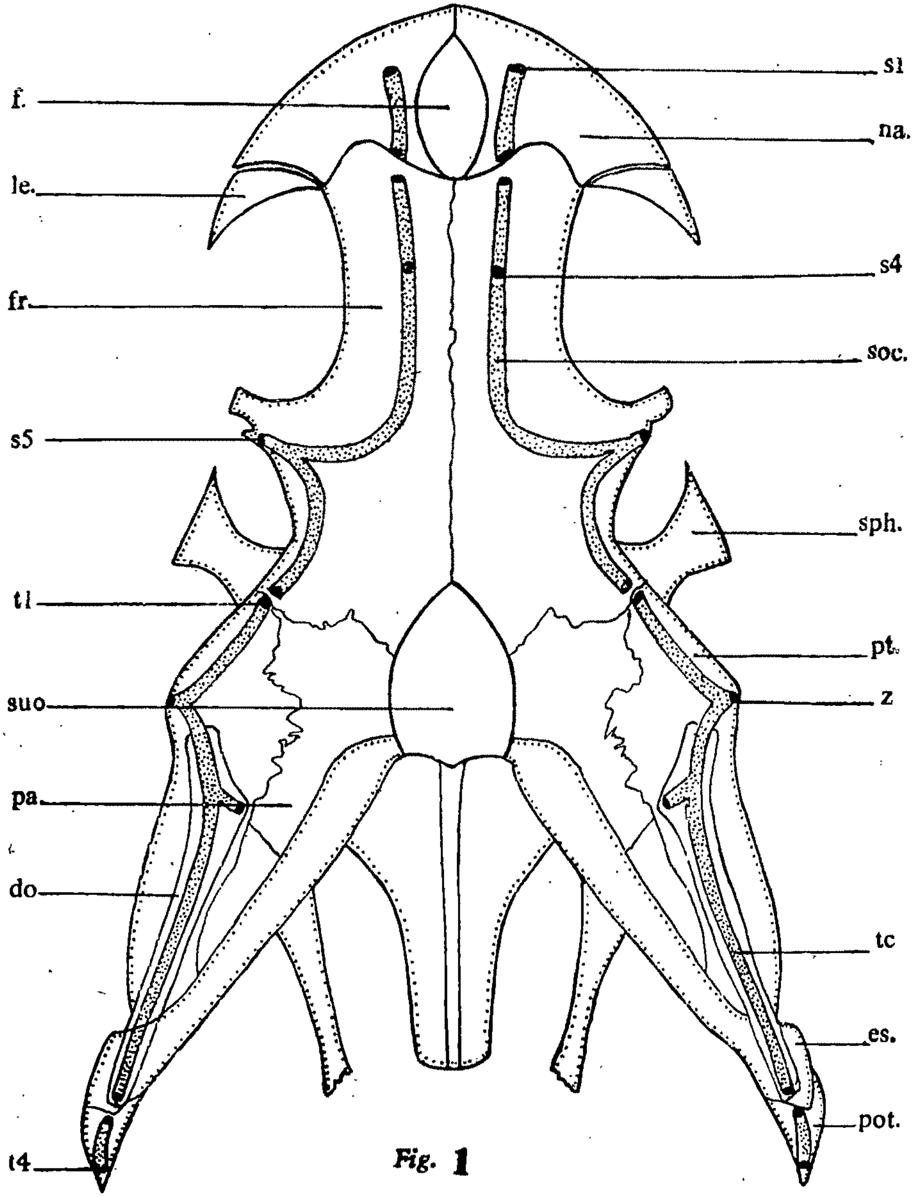
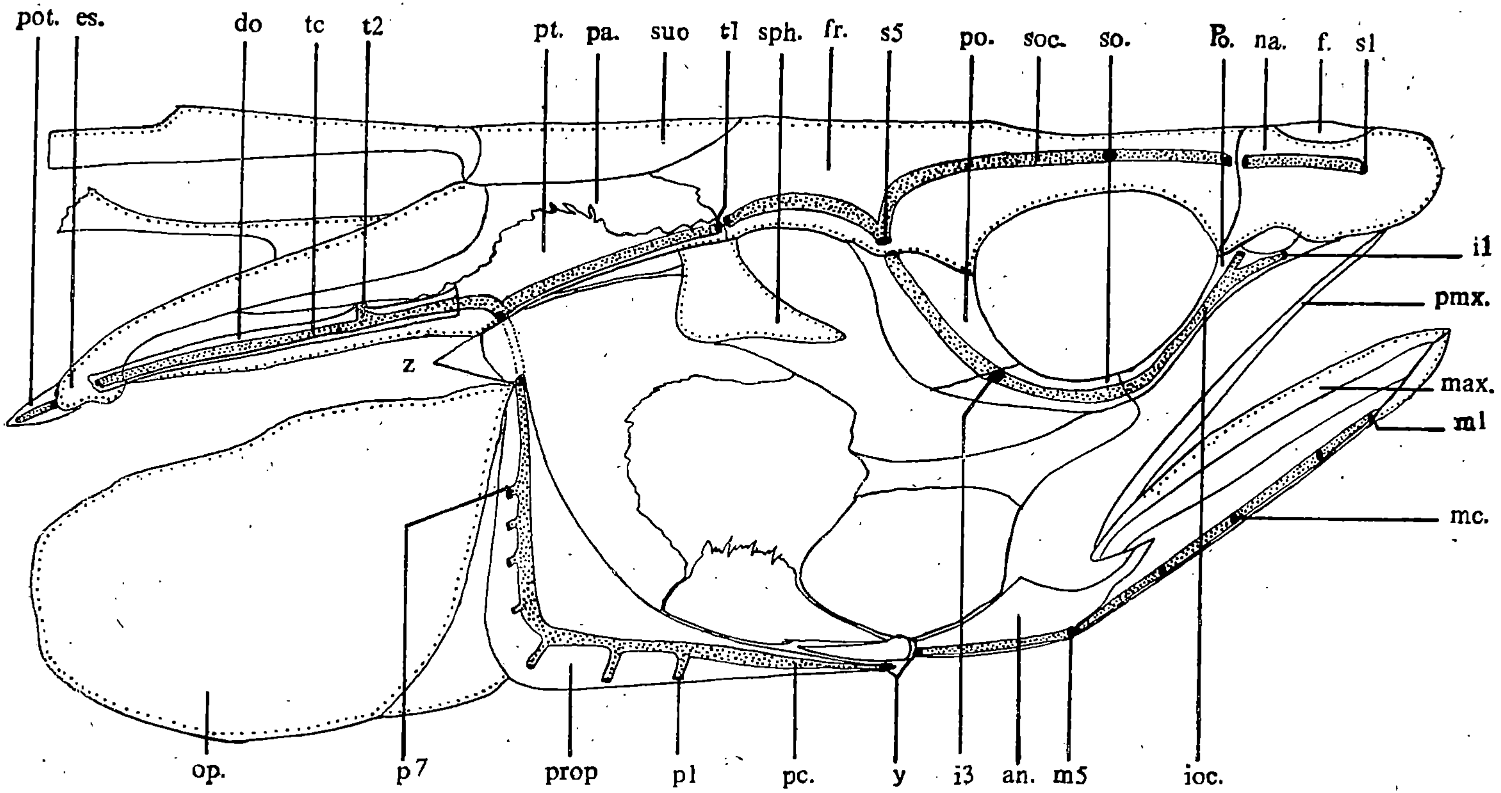


Fig. **1**

DORSAL VIEW

RHINOMUGIL CORSULA (HAM.)



LATERAL VIEW

Fig. **2**

THE MORPHOLOGY AND HISTOLOGY OF THE ALIMENTARY CANAL OF *HETEROPNEUSTES FOSSILIS* (BLOCH)

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INTRODUCTION

Heteropneustes fossilis is one of the common fishes found from the fresh waters of India. The present investigation is concerned with the morphology and histology of its alimentary canal.

On the alimentary canal references can be made to Greene (1912), Purser (1928-1929), Ben Dawes (1929), Rogick (1931), Blake (1930 & 1936), Vanajakshi (1938), Kapoor (1953), Pillay (1953), Weinreb & Bilstad (1955) and Nagar & Khan (1958).

Accounts on alimentary canal correlated with the habits are from Blake (1930 & 1936) and Al Hussaini (1946-1949).

OBSERVATIONS

Morphology (Figs. 1 & 2)

The alimentary canal is a long tube of variable diameter with the intestinal part thrown into coils.

The *mouth* is transverse and subterminal. The jaws are armed with inwardly directed villiform teeth, the premaxillary teeth on upper jaw and mandibular teeth on lower jaw. Along the inner edge of the two jaws are upper and lower lips, which are inwardly directed pockets serving as valves.

The *buccal cavity* has a feebly developed tongue, which is attached to it by the lower surface. On the roof of buccal cavity, just behind the upper lip are present two patches of villiform vomerine teeth, which are directed backwards.

The *pharynx* is wider than the buccal cavity and is perforated on the sides by gill-slits fringed with teeth-like gill rakers. Between the second and third gill arch is the opening of the air-sac on either side. A little before the gullet is a pair of oval superior pharyngeal teeth on the roof and a pair of crescentic inferior pharyngeal teeth on the floor which oppose each other. These teeth divide the pharynx into a region in front and a region behind them, which are also marked on the basis of mucosal lining. In the anterior division of pharynx the mucosa is smooth, while in the posterior it is thrown into longitudinal folds, which continue into the gullet.

The *oesophagus* is in the form of a small and muscular tube, concealed in the ventral view by the lobes of liver. Its mucosal lining is thrown into longitudinally running prominent folds continuous with those of the gullet and stomach. On the dorsal side of the oesophagus is the opening of pneumatic duct.

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The *stomach* is U-shaped and is situated in the anterior part of visceral cavity. Its proximal sac-like limb is the cardiac division and the distal tube-like limb is the pyloric division. The mucosal folds of the cardiac division are very prominent and branched, while of the pyloric division are less prominent and longitudinally disposed.

The *intestine* is thin and tube-like and it constitutes the major part of alimentary canal. Its anterior two-third part is thrown into a few coils, while its posterior one-third running longitudinally in the middle line opens to the exterior by the slit-like anus. At the junction of the pyloric stomach and the intestine is the pyloric sphinctor as a backwardly directed infolding from the wall of pyloric stomach. Just behind this sphinctor the intestine receives the bile-duct. The intestine is distinguished into equally long anterior and posterior parts on the basis of the thickness of its wall and the nature of mucosal folds. The anterior intestine is comparatively thin-walled than the posterior intestine. The folds are thin and honey-combed in the anterior intestine, while they are thick and longitudinally disposed in posterior intestine.

Histology (Figs. 3-10)

The mucosa of the *buccal cavity* is stratified and distinguishable into the stratified layer, rete mucosum Malpighii and stratum Malpighii. The stratified layer is several cells thick and is composed of compactly held polygonal cells. In it are present the mucous cells and taste buds. The mucous cells run in a layer along the periphery of stratified layer. Each cell is oval in form and is with a crescentic nucleus at the base. The taste buds are few and wide apart. Each is pear-shaped with the base reaching up to the middle of rete mucosum Malpighii. It is composed of elongated gustatory and supporting cells, surrounded by a mass of connective tissue. The rete mucosum Malpighii is composed of two to three layers of loosely held oval cells. In it are also present large clavate cells, which are oval and with central nuclei. A few mucous cells are also met with in this layer. The stratum Malpighii is formed of columnar cells, which are compactly held and run in three to five layers. The cells of stratum Malpighii gradually pass upwards into the cells of rete mucosum Malpighii. The subepithelial connective tissue is a dense network of horizontally disposed fibres with interspersed blood capillaries and nerve endings. A structureless basement membrane separates the mucosa from the subepithelial connective tissue. The subepithelial connective tissue is a compact mass of fibres with nuclei and blood capillaries.

The *anterior pharynx* is similar to the buccal cavity histologically. The mucosa of *posterior pharynx* is thrown into folds. Its subepithelial connective tissue is distinguished into a dense part in the mucosal folds and a loose part below the folds. In the loose part are longitudinally running and obliquely disposed muscle fibres of striated type. The basement membrane is present between the mucosa. The taste buds are rare in the buccal cavity and pharynx.

The mucosa of the *oesophagus* is stratified. Among the usual cells are the clavate and mucous cells, which are abundantly present and cover the inner part of this layer. The taste buds are wanting. The tunica propria is composed of loosely held fibres, while the submucosa is formed of compactly held fibres and lodges the bundles of longitudinally running muscle fibres. A thick vascular serosa invests the muscularis.

The mucosa of the *stomach* is single-layered and forms crypts. The cells of mucosa of the *cardiac stomach* are trumpet-shaped at the tips of folds, columnar at the sides of crypts and roughly cubical at the bottom of crypts. Each cell contains an oval nucleus in its distal-third. The tubular and branched gastric glands are separated by septa of tunica propria. Each gland opens into the crypts without the intervention of neck cells. Each gland-cell has a central nucleus and is filled with zymogen granules. Numerous wandering cells lie in the tunica propria. The muscularis and serosa are of the usual type. In the *pyloric stomach* gastric glands are absent and the cells of mucosa are comparatively less taller than those of cardiac stomach. The layer of circularly disposed muscle fibres is exceptionally thick. In addition to the usual muscularis a second belt of longitudinally disposed muscle fibres is present in the submucosa near the pyloric sphinctor.

The mucosa of *intestine* is covered by thin top-plate. The mucosa of the *anterior intestine* is formed of the columnar cells and pear-shaped mucous cells. The tunica propria contains wandering cells, which get stratified just beneath the mucosa. The submucosa is areolar and is in a thin belt. The layers of the circularly disposed and longitudinally running muscle fibres are thin and of equal thickness. In the *posterior intestine* the mucous cells are absent and the columnar cells are comparatively taller than in the anterior intestine. The muscularis is thick and its two layers are equally developed.

DISCUSSION

A good number of references are on record on the digestive organs of fishes. While Purser (1928-29), Sarbahi (1939) and Kapoor (1953) dealt with the complete digestive organs, Greene (1912), BenDawes (1929), Blake (1930 & 1936), Mohsin (1945), Al Hussaini (1946-47) and Pillay (1953) worked on the alimentary canal alone. Rogick (1931), Vanajakshi (1938), Curry (1939) and Ahsan ul islam (1951) described only the histology of alimentary canal.

The present discussion is mostly based on the variations from the earlier account of Vanajakshi (1938) on the same fish. While Vanajakshi has dealt with the histological details only, the present paper includes the gross morphology of the canal as well. The present enquiry also differs from that of Vanajakshi in a number of interesting points, which are enumerated below :

1. Vanajakshi did not distinguish the intestine into anterior and posterior intestine, which has been observed in the present work on the basis of nature of mucosal folds and the thickness of the wall.

2. She mentioned the stratified mucosa of the buccal cavity composed of the mucous cells, giant cells and undifferentiated cells. In this work the stratified mucosa has been distinguished into the stratified layer, rete mucosum Malpighii and stratum Malpighii. Vanajakshi noted the taste buds in abundance in the buccal and pharyngeal mucosa. In the present work the taste buds in the buccal and pharyngeal mucosa have been found to be rare. She did not distinguish the basement membrane between the mucosa and subepithelial connective tissue of the buccal cavity and pharynx, which has been noted in the present investigation. Vanajakshi distinguished the subepithelial connective tissue of the buccal cavity into a belt of loosely held and another belt of compactly held fibres and a layer of circular muscularis in the pharynx. The subepithelial connective tissue of the buccal cavity in the present work, is observed to be composed of compactly held fibres only and the circularly disposed muscle fibres have not been made out in the pharynx.

3. She noted few taste buds in the oesophageal mucosa, which is not confirmed by the present work. The subepithelial connective tissue of oesophagus was also not distinguished by her into loose tunica propria and compact submucosa.

4. Vanajakshi did not make out the wandering cells in the tunica propria of the cardiac stomach and no mention was made by her of the presence of an additional layer of longitudinally disposed muscle fibres in the submucosa of pyloric stomach. These have been noted in the present work.

5. According to Vanajakshi mucous cells are present throughout the intestinal mucosa, which in the present work have been observed in the mucosa of anterior intestine only. The two belts of intestinal muscularis were noted by her of unequal thickness, while in the present work they have been noted of nearly equal thickness.

ACKNOWLEDGEMENTS

I am indebted to Dr. B. M. Sinha for the guidance in the course of work. My thanks are also due to Dr. Radhey Shiam for his help in photographing of the figures. My acknowledgements are also due to the authorities of Meerut College for providing me the facilities for the work.

SUMMARY

1. The subterminal mouth is guarded by the upper and lower jaws, which are provided with the inwardly directed villiform teeth and inner lips. The vomerine, superior pharyngeal and inferior pharyngeal teeth are present.

2. The stratified mucosa of the buccal cavity and pharynx has been distinguished into the stratified layer, rete mucosum Malpighii and stratum Malpighii. The clavate cells are abundantly present and the taste buds are very few. In the subepithelial connective tissue of the pharynx are bundles of longitudinal muscle fibres. The mucosa of the oesophagus is stratified and contains the mucous and clavate cells.

3. The gastric glands of the cardiac stomach open directly into the crypts. In the pyloric stomach is an additional layer of longitudinally disposed muscles in the submucosa internal to the usual muscularis.

4. A top-plate invests the mucosa of intestine. The mucosa is formed of the columnar cells, invaded at their bases by wandering cells. In the mucosa of the anterior intestine mucous cells are also present.

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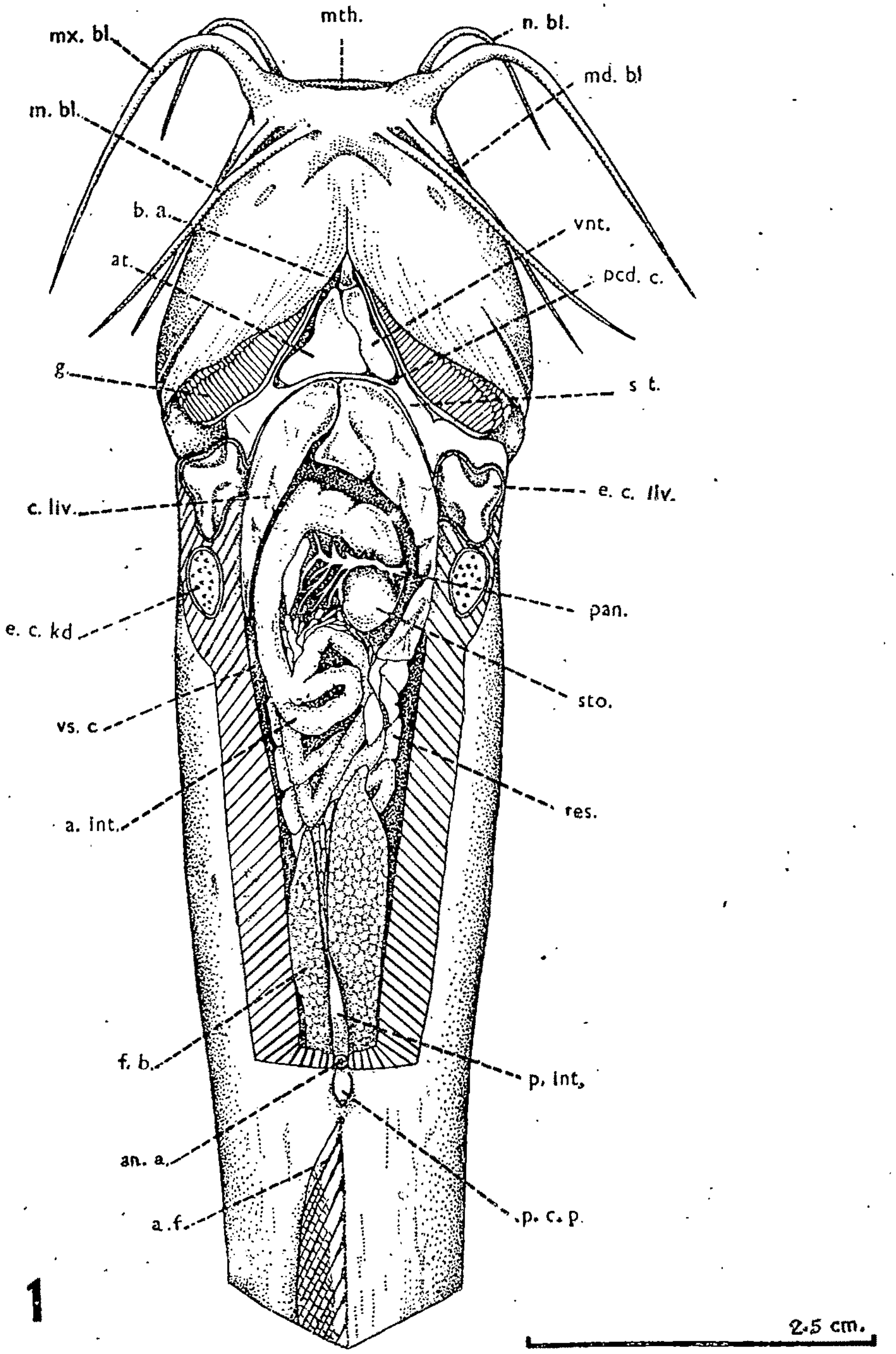

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Fig. 1. Ventral view of the internal viscera in a male fish.
an.a., anal aperture; *a.f.*, anal fin; *a. int.*, anterior intestine; *at.*, atrium; *b.a.*, bulbous aorta; *c.liv.*, coelomic liver; *e.c.kd.*, extra coelomic kidney; *e.c.liv.*, extra coelomic liver; *f.b.*, fat body; *g.*, gill; *m.bl.*, mental barbel; *md.bl.*, mandibular barbel; *mx.bl.*, maxillary barbel; *mth.*, mouth; *n.bl.*, nasal barbel; *pan.*, pancreas; *pcd.*, pericardial cavity; *p.c.p.*, pseudo copulatory papilla; *p.int.*, posterior intestine; *sto.*, stomach; *s.t.*, septum transversum; *tes.*, testis; *vnt.*, ventricle; *vs.c.*, visceral cavity.

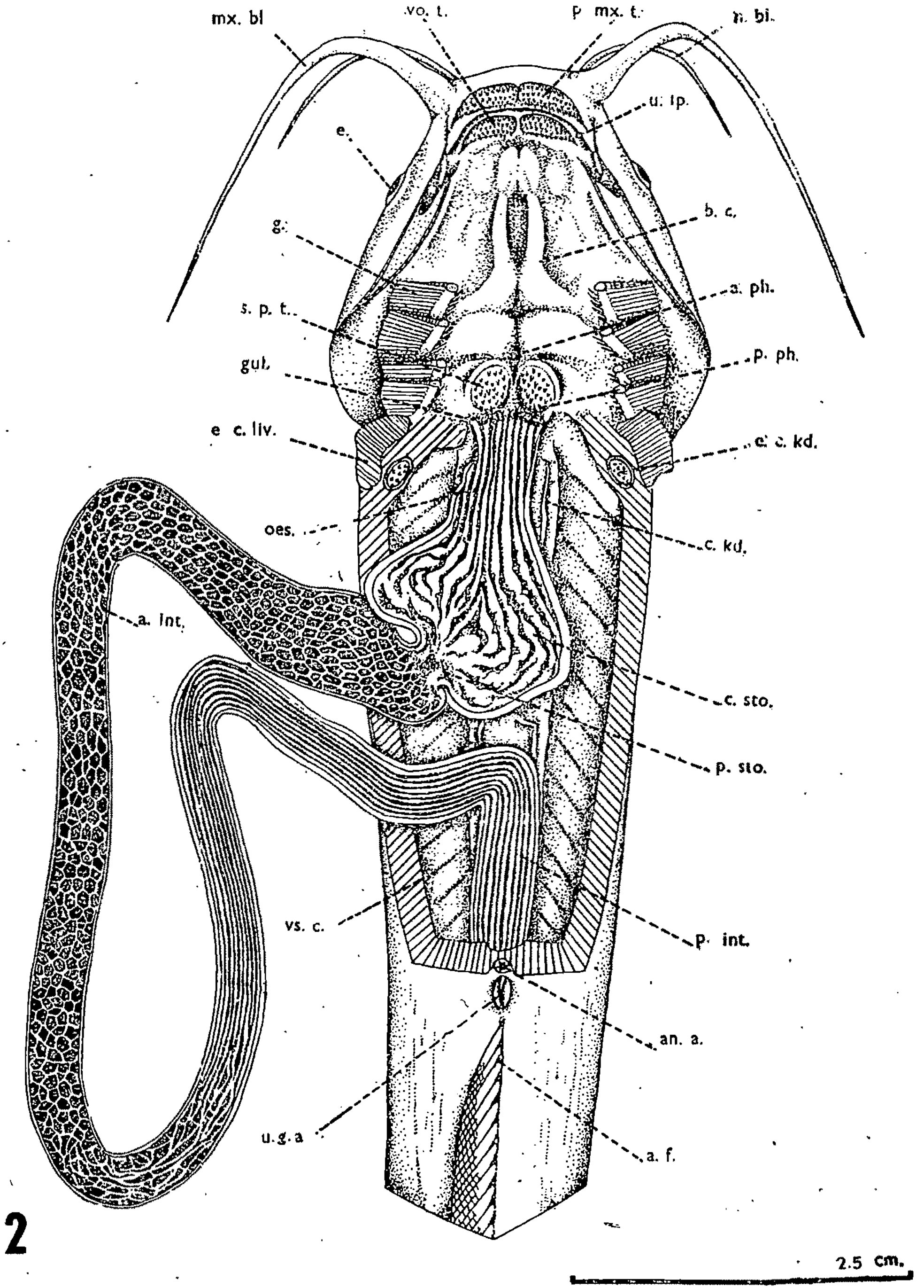

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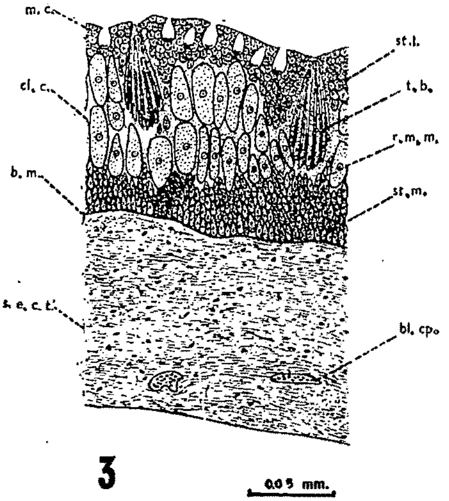
Fig. 2. Ventral view of the internal viscera showing the dissected alimentary canal.
a.int., anterior intestine; *a.f.*, analfin; *an.a.*, anal aperture; *a.ph.*, anterior pharynx; *b.c.*, buccal cavity; *c.kd.*, coelomic kidney; *c.sto.*, cardiac stomach; *e.c.kd.*, extra coelomic kidney; *e.c.liv.*, extra coelomic liver; *e.*, eye; *g.*, gill; *gul.*, gullet; *mx.bl.*, maxillary barbel; *p.mx.t.*, premaxillary teeth; *n.bl.*, nasal barbel; *oes.*, oesophagus; *p.ph.*, posterior pharynx; *p.int.*, posterior intestine; *p.sto.*, pyloric stomach; *s.p.t.*, supra pharyngeal teeth; *u.lp.*, upper lip; *vs.c.*, visceral cavity; *vo.t.*, vomerine teeth.



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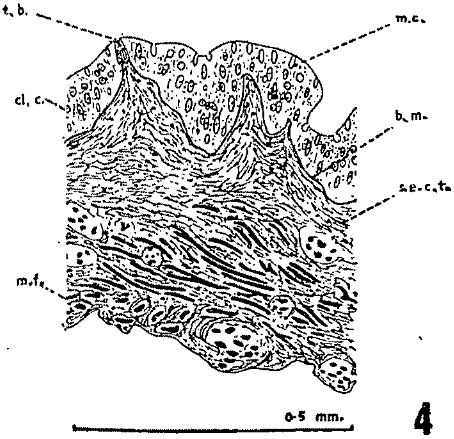

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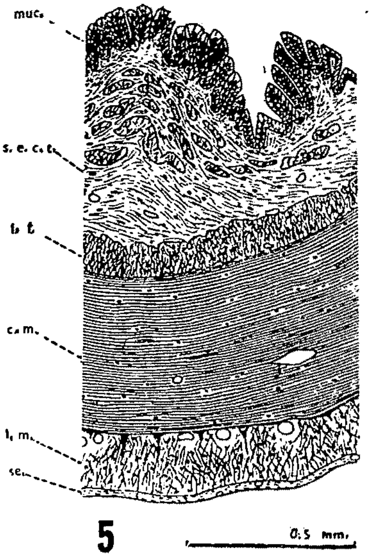

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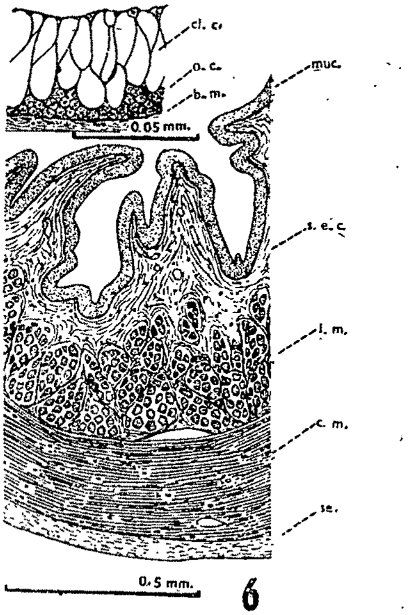

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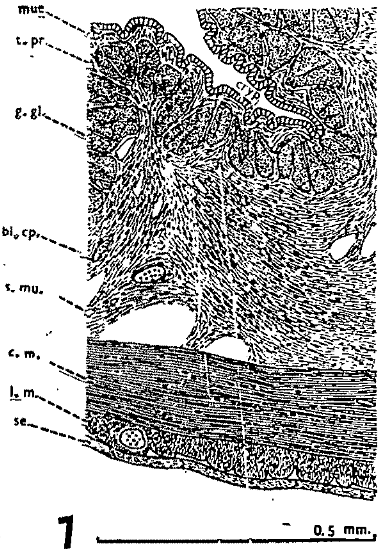
Fig. 3. Vertical section of the lining of buccal cavity.
Fig. 4. Vertical section of the lining of pharynx.
Fig. 5. Transverse section through pyloric stomach near pyloric opening.
Fig. 6. Transverse section through oesophagus; a part of the mucosa magnified.

bl.c., blood capillary; *b.m.*, basement membrane; *cl.c.*, clavate cell; *c.m.*, circular muscles; *l.m.*, longitudinal muscles; *m.c.*, mucous cell; *muc.*, mucosa; *m.f.*, muscle fibre; *o.c.*, ordinary cell; *r.m.m.*, rete mucosum Malpighii; *s.e.c.t.*, subepithelial connective tissue; *se.*, serosa; *st.l.*, stratified layer; *st.m.*, stratum Malpighii; *t.b.*, taste bud.



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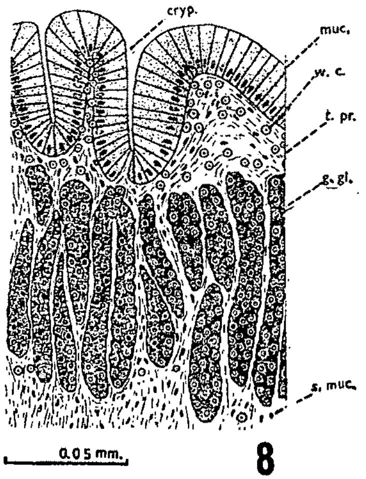

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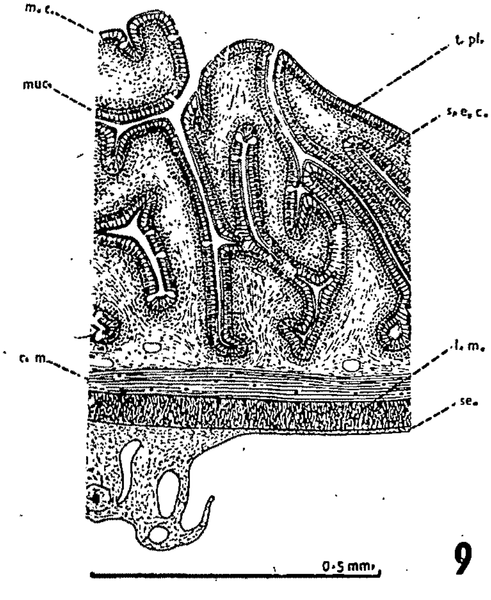

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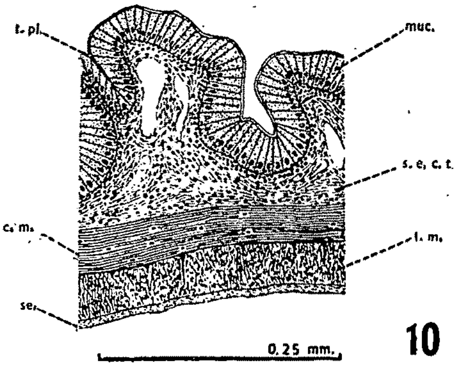

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Fig. 7. Transverse section through cardiac stomach.
Fig. 8. Part of mucosa under magnification.
Fig. 9. Transverse section through anterior intestine.
Fig. 10. Transverse section through posterior intestine.

b.c., blood capillary; *c.m.*, circular muscles; *cryp.*, crypt; *g.l.*, gastric gland; *l.m.*, longitudinal muscles; *muc.*, mucosa; *m.c.*, mucous cell; *se.*, serosa; *s.e.c.t.*, subepithelial connective tissue; *s. mu.*, sub mucosa; *t.pl.*, top plate; *t.p.*, tunica propria; *w.c*, wandering cell.

STUDIES ON THE HEART OF *CHILOSCYLLIUM INDICUM* (GUNTHER)

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INTRODUCTION

The Elasmobranch fish *Chiloscyllium indicum* is available fairly in large numbers from the Indian Seas. But for the studies pertaining to the reproductive system and the development of this fish, there is a great paucity in our knowledge about its anatomy. The author in the present paper deals with the anatomy of its heart.

HISTORICAL RESUME

Parker and Davis (1899) made a morphological study of the heart in *Carcharias* and *Raja*. Parsons (1929) probed into the disposition of the valves within the conus arteriosus of the heart in *Raia batis, Raia clavata, Scyllium canicula* and *Pristiurus melanostonus.* Goodrich (1930) has given an excellent consolidated account of the heart in Elasmobranch fishes. Thillayampalam (1938) has described the heart of *Scoliodon sorrakowah.*

MATERIAL AND TECHNIQUE

Living specimens of *Chiloscyllium indicum* were collected by the crew of the State Fishing Boat from the Indian Ocean two to three miles off Azhicode. After slitting open the ventral body wall some of the fish were preserved in 10% formalin for about a week before being taken out for careful dissection of the heart under a powerful Binocular Microscope. The minute anatomy of the heart was studied in serial sections 10 micra thick in transverse and sagittal planes prepared according to the paraffin embedding process. These were stained either with Mallory's Triple Stain or in a few cases with Delafield's Haematoxylin and Eosin.

THE HEART

(a) *General account:*

The heart lies immediately posterior to the visceral arches very close to the gills and is slightly anterior to the coracoid cartilage of the pectoral girdle. The heart is a four chambered organ consisting of the Sinus venosus, the Atrium, the Ventricle and the Conus arteriosus enclosed within the pericardium.

(b) *The Pericardium:*

The pericardium is a thin walled bag-like structure. Although anteriorly very narrow, it gets steadily increased in size posteriorly until its wide base extends immediately anterior to the liver lobes.

(c) *The chambers of the Heart:*

(i) *The Sinus venosus*—The sinus venosus (Fig. 1.), the posteriormost chamber of the heart, is a thin walled triangular structure extending transversally across the posterior wall of the pericardial cavity to which it is attached. The cardiac muscle fibres constituting the wall of the sinus venosus form an extremely thin and compact layer. They do not, however, cross and recross each other. Hence the wall of the sinus venosus is not spongy; nor is the lumen of the sinus venosus divided by any trabeculae extending from its wall.

(ii) *The Atrium*—The atrium (Fig. 1) is a thick walled triangular chamber situated immediately anterior to the sinus venosus and dorsal to the ventricle. The anterior region of the atrium extends over a considerable length of the conus arteriosus while posteriorly the two posterior lobes of the atrium extend much behind the posterior region of the ventricle.

In transverse sections the atrium is seen to consist of a median and two lateral lobes, the latter being disposed adjacent to the ventricle. The atrial wall is to some extent spongy due to the crisscross disposition of the cardiac muscle fibres (Fig. 2).

There is a prominent strand of trabecula composed of cardiac muscle fibres extending along the middle of the floor of the atrium in the antero-posterior direction and dividing the atrial floor into a right and a left half. Associated with this trabecula there is an annular trabecula situated towards the posterior region of the left half of the atrial floor and encircling the atrio-ventricular aperture (Fig. 3).

The atrium opens into the ventricle by means of the atrio-ventricular aperture which is guarded by four valves—a pair of major valves and a pair of minor valves. (Fig. 4).

(iii) *The Ventricle*—The ventricle (Fig. 1) is a pear shaped structure with a very thick muscular wall. There is a thick compact layer of cardiac muscle fibres forming the outermost part of the ventricle. Enclosed by this layer, there are numerous bundles of cardiac muscle fibres varying a great deal in their configuration and disposition around the central lumen of the ventricle (Fig. 5.). The ventricular wall is spongy in its texture because of the crossing and recrossing of its numerous strands of cardiac muscle fibres.

(iv) *The Conus arteriosus*—The conus arteriosus (Fig. 1) is a short cylindrical tube the lumen of which is continuous with that of the ventricle. The conus has fairly a thick wall and a circular lumen. The greater part of the wall of the conus arteriosus is made-up of a thick and compact layer of the cardiac muscle fibres (Fig. 6) which are imperceptibly continued into the ventricle where they intermingle with the fibres of the ventricle itself (Fig. 5). There is a thin layer of loose connective tissue fibres investing the muscular layer of the conus arteriosus (Fig. 6).

Study of the serial transverse and sagittal sections of the conus arteriosus has substantiated that inside the conus arteriosus there is a single tier of three pocket valves—one dorsal and the other two ventro-lateral in disposition (Fig. 6) and (Fig. 7). Extremely fine tendinous threads extending from the valves and passing into the wall of the conus arteriosus serve to hold the valves in position.

THE WORKING OF THE HEART

The sinus venosus collects the returning venous blood from the two ducts of Cuvier and the two hepatic veins. When the sinus venosus is filled with blood, it contracts. The blood now flows into the atrium through the sinu-atrial aperture, the reflux of the blood being prevented by the sinu-atrial valves. The blood from the atrium flows into the ventricle through the atrio-ventricular aperture, on the contraction of the atrium. Next the ventricle contracts, but the regurgitation of the blood into the atrium is prevented by the four atrio-ventricular valves. The blood now reaches the conus arteriosus. On the contraction of the conus arteriosus the blood flows into the ventral aorta and the associated blood vessels, the backward flow of the blood into the ventricle being prevented by the three pocket valves within the conus arteriosus.

DISCUSSION

Goodrich (1930) has described the presence of a pair of obliquely set valves guarding the atrio-ventricular aperture in the heart of the Elasmobranch fishes. Thillayampalam (1938) reported the occurrence of a bilabiate valve at the atrio-ventricular aperture in the heart of *Scoliodon sorrakowah.* de Beer (1951) and Weichert (1958) have mentioned that the atrio-ventricular aperture is guarded by a single pair of valves in *Scyllium canicula* and *Squalus acanthias* respectively. In *Chiloscyllium indicum* I have, however, observed the presence of a circle of four valves at the atrio-ventricular aperture; two of these valves are larger than the other two.

According to Goodrich (1930) the number of the valves within the conus arteriosus of the Elasmobranch fishes varies considerably. In *Chimaera* and some of the Sharks there are two tiers of valves, each tier consisting of three valves. Parsons (1929) studied the distribution of the valves in the conus-arteriosus of some Elasmobranch fishes. He noted the occurrence of five circles of valves in *Raia batis* and *Raia clavata,* three circles of valves in *Scyllium canicula* and two circles of valves in *Pristiurus melanostonus.* Thillayampalam (1938) observed in the conus arteriosus of *Scoliodon sorrakowah* the presence of two transverse rows of semi-lunar valves, each row containing three valves, besides a small accessory valve on either side of the dorsal valve.

In the conus arteriosus of *Chiloscyllium indicum* great reduction in the number of the valves has been observed. There is, however, only a single tier of three valves—one dorsal and the other two ventro-lateral in disposition.

SUMMARY

1. The atrio-ventricular aperture is guarded by a circle of four valves, two of which are larger than the other two.

2. Traversing through the middle of the atrial floor there is a prominent muscular trabecula which gives rise to an annular trabecula encircling the atrio-ventricular aperture.

3. The greater part of the wall of the conus arteriosus is made-up of cardiac muscle fibres.

4. There are three pocket valves within the conus arteriosus.

ACKNOWLEDGEMENTS

I am greatly thankful to Dr. C. P. Singh of Agra College, Agra for loaning me the relevant literature on the heart of Elasmobranch fishes, to Rev. Fr. A. Gabriel, C.M.I., Principal of Christ College, Irinjalakuda for encouragement and for the facilities placed at my disposal and to Mrs. Achamma Thomas for a great deal of assistance. I am also indebted to Mr. P. D. Varghese for supplying me with numerous specimens of *Chiloscyllium indicum.*

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ABBREVIATIONS USED IN THE FIGURES

A.	Atrium.
A.T.	Annular trabecula.
A.V.A.	Atrio-ventricular aperture.
C.A.	Conus arteriosus.
C.D.	Cuvierian duct.
C.M.F.	Cadiac muscle fibres.
C.T.	Connective tissue.
D.V.	Dorsal valve in the conus arteriosus.
H.V.	Hepatic vein.
L.B.A.	Lateral lobe of the Atrium.
L.T.	Longitudinal trabecula.
M.E.	Major atrio-ventricular valve.
M.B.A.	Median lobe of the atrium.
M.I.V.	Minor atrio-ventricular valve.
P.	Pericardium.
S.V.	Sinus venosus.
V.	Ventricle.
V.A.	Ventral aorta.
V.L.	Ventricular lumen.
V.L.V.	Ventro-lateral valve in the conus arteriosus.

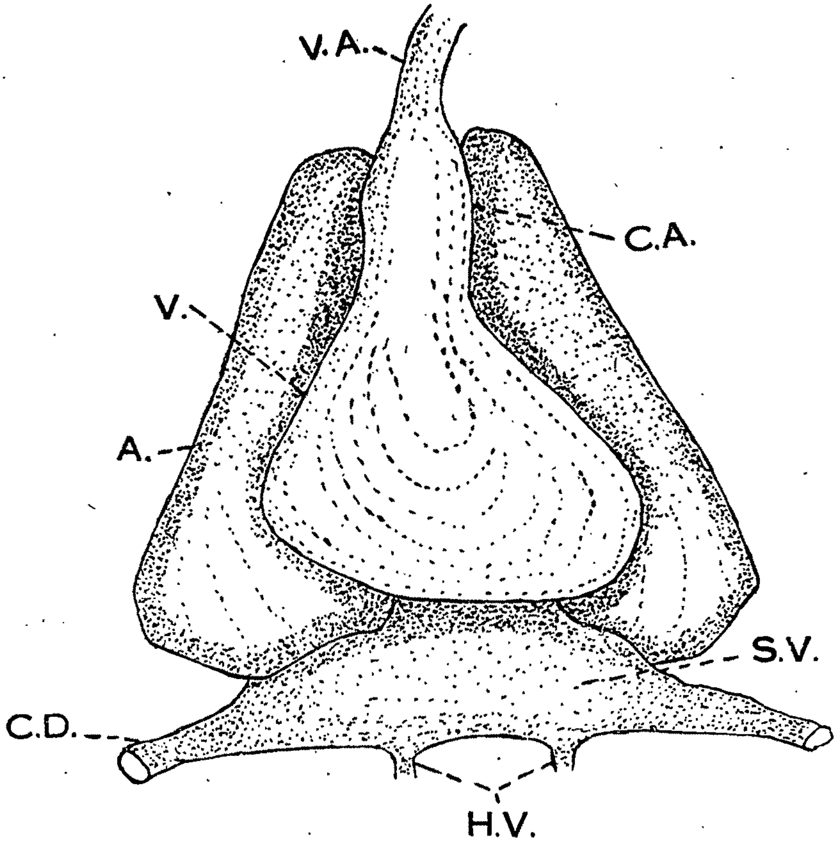

Fig. 1. The ventral view of the Heart. X 6.

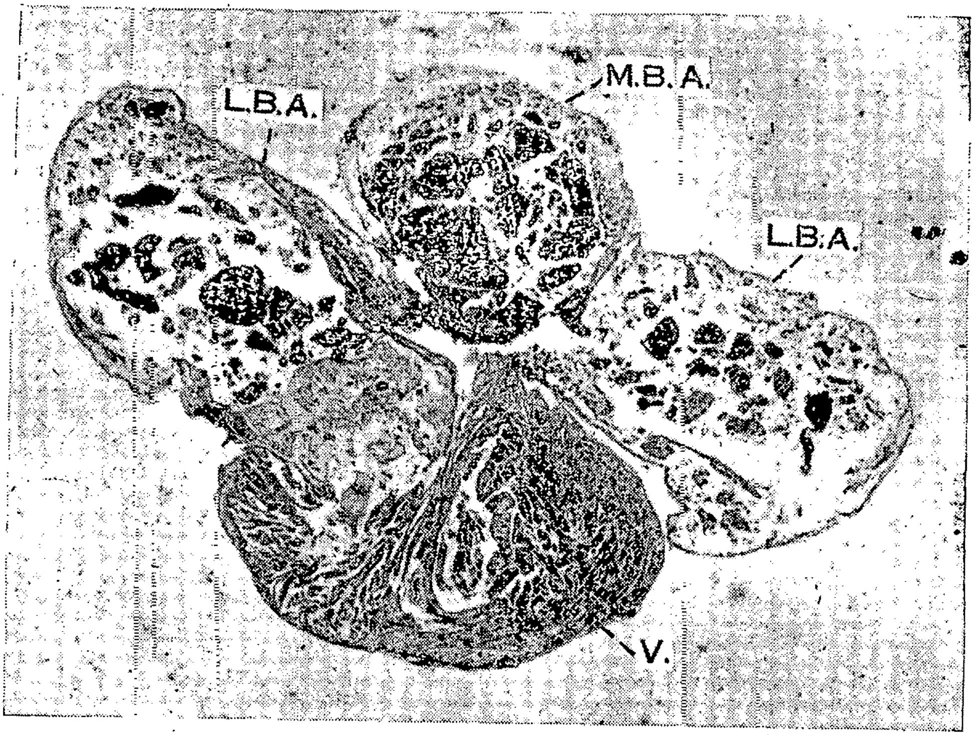

Fig. 2. Transverse section of the Heart passing through the atrium and the ventricle. X 200.

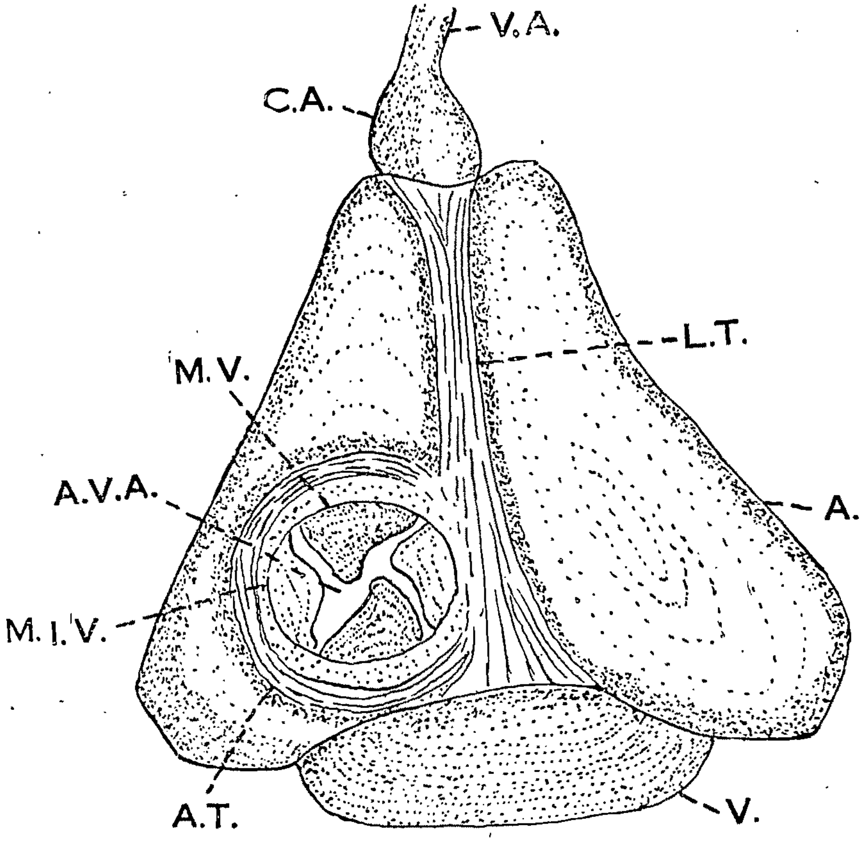

Fig. 3. The Heart after the removal of the roof of the atrium. X 6.

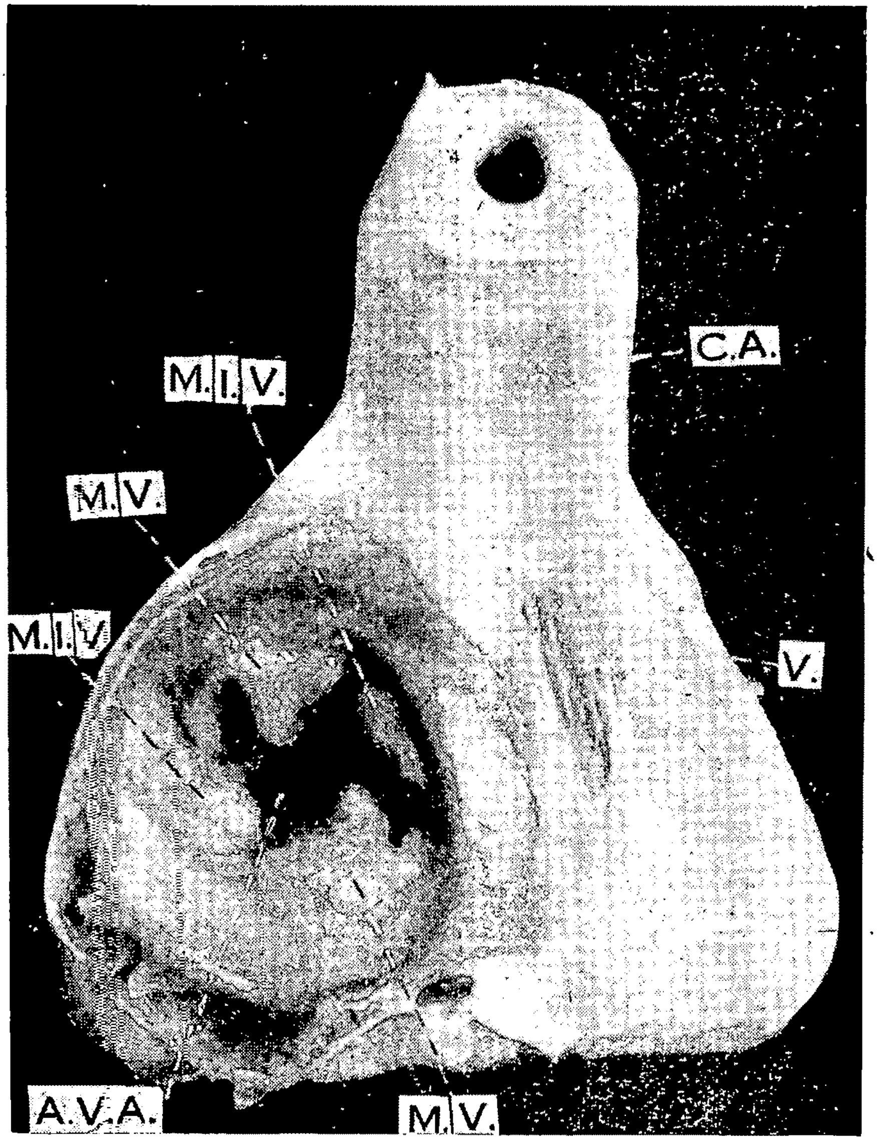

Fig. 4. The Heart showing the atrio-ventricular valves, after the removal of the atrium. x15.

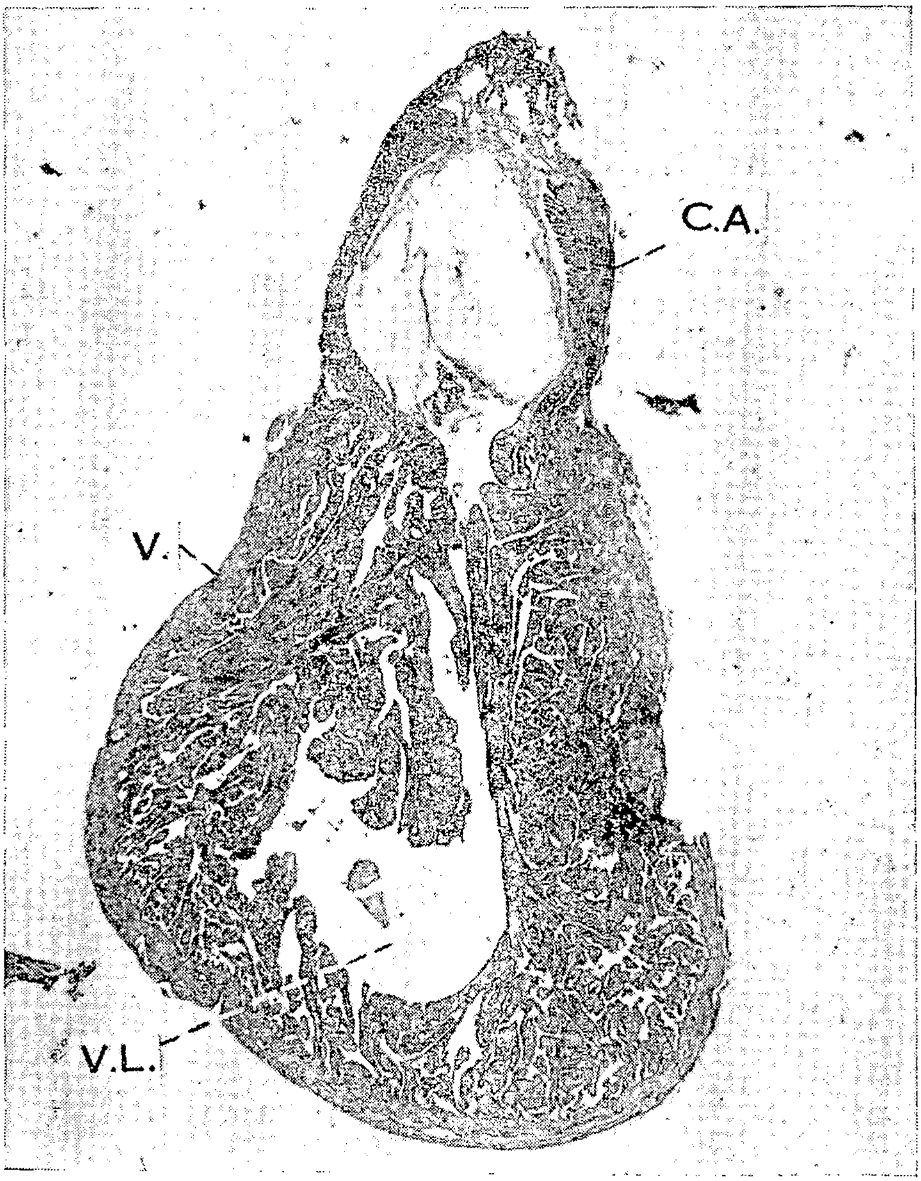

Fig. 5. Sagittal section of the heart passing through the conus arteriosus and the ventricle, X 200

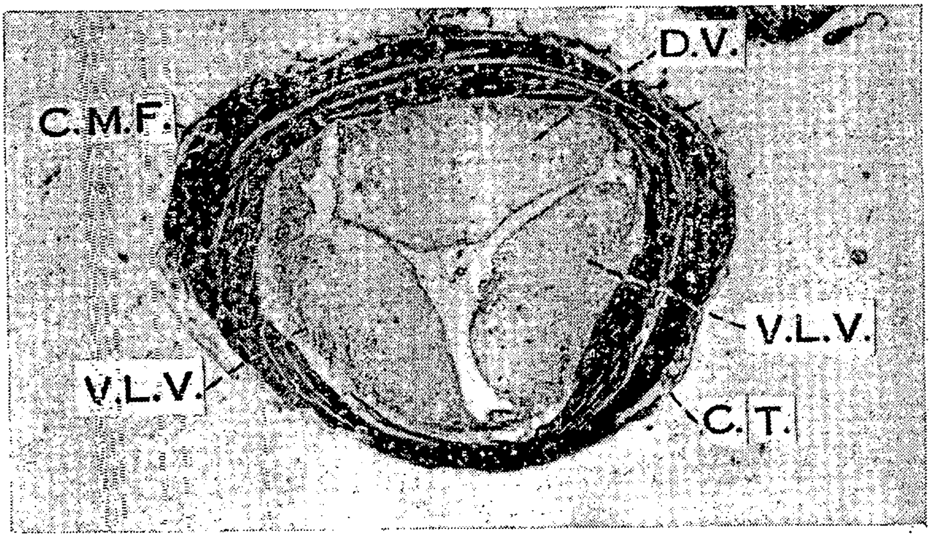

Fig. 6. Transverse section of the conus arteriosus. X 200.

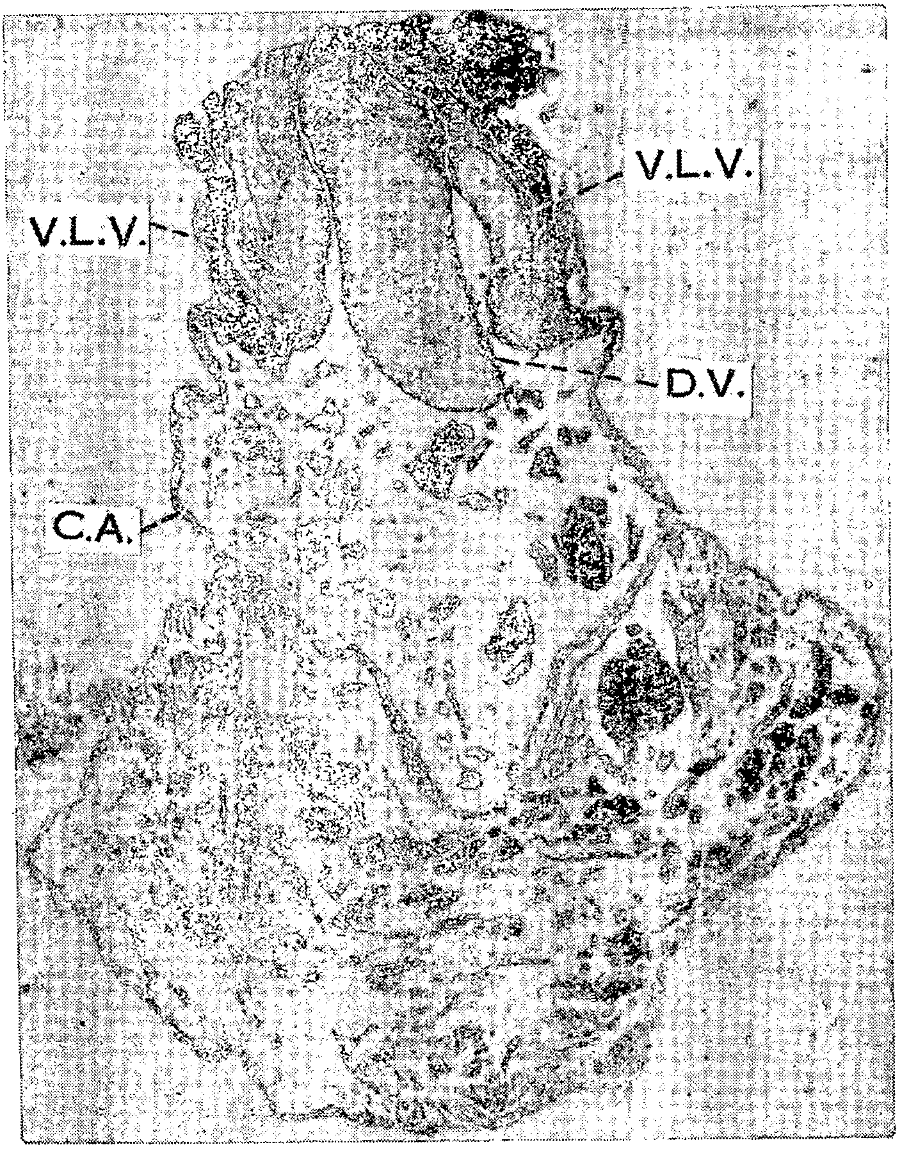

Fig. 7. Sagittal section of the conus arteriosus. X 200.

STUDIES ON THE MINERAL METABOLISM UNDER ACID AND ALKALI PRODUCING DIETS IN SHEEP

[UTILIZATION OF CALCIUM, PHOSPHORUS AND SULPHUR]

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Utilisation of minerals from a ration is a complex problem and is governed by numerous factors—the nature of feeds being of considerable significance. With paddy straw as the roughage, calcium (CaO) and phosphorus (P_2O_5) requirements for a bullock weighing 500 lb. were determined to be 24 and 10 gm. respectively (Carbery et al., 1937) while with wheat *bhusa* the corresponding amounts are 17 and 11 gm. as reported by Kehar and Qureshi (1941).

Patel et al., (1961) reported in cattle positive balances with an intake of 9·2 and 15·3 gm. of calcium and phosphorus respectively along with wheat straw and negative balances with *bavto* straw (Eleusine Coracana) even with the corresponding intakes of 44·3 and 30·8 gm. of calcium and phosphorus.

Wheat *bhusa* and paddy straw are reported to be the acid and alkali producing roughages respectively in the animal system (Sen, 1953) and it is not unlikely that the divergence in the utilisation of minerals as indicated above may be governed by this fact. What happens in sheep in similar situation is not known and the present study is an attempt in the same direction.

EXPERIMENTAL

Six 'Magra' rams of similar body weight, size, age and general condition were selected as the experimental subject. The rams were dewormed before starting the preliminary feeding. Two digestion trials on ration I and II were conducted one after the other on the same set of rams. The details of the experimental rations are as follows :—

Ration I. (i) Wheat *bhusa* (ad-lib.)
(ii) Concentrate mixture—
(a) G.N. Cake 40%
(b) Maize grain. 60%
(iii) Green paragrass—250 gm/head/day.
(iv) Common Salt—10 gm./head/day.

Ration II. The same as in ration I except wheat *bhusa* which was replaced by paddy straw.

The amount of concentrate mixture fed to each animal was determined on the basis of the protein requirement according to Morrison's recommendations. Green paragrass was provided equally in both the trials. Water was given free choice to each animal in the experimental stall.

The metabolic trial was divided into a 20-day preliminary and a 10-day collection period.

The faeces and urine were collected by the conventional method. The proximate principles and sulphur were estimated according to the procedure laid down by A.O.A.C. (1955 ed.). The determination of calcium and phosphorus was done by the modified method reported by Talapatra, Ray and Sen (1940). The procedure described by Talapatra et al. (1948a) was used for the estimation of oxalate as oxalic acid.

Results and Discussion

The results of the present project have been discussed under the following heads :—

(a) Chemical composition of the experimental rations.
(b) Palatability of the rations as judged by the dry matter consumption.
(c) Digestibility coefficients.
(d) Balances of nitrogen, calcium, phosphorus and sulphur.
(e) Dry matter, Digestible crude protein, total digestible nutrients, calcium, phosphorus and sulphur intake in relation to the Morrison's feeding standard (1956).

Per cent Chemical Composition of the Experimental Rations

The chemical constituents of the various components of the two experimental rations have been detailed in table 1.

Normally one would expect all the supplements of the two basic roughages in the two rations to have the same composition, but as the supplements for the two experiments were procured separately, they showed variation in some of the chemical constituents (table 1).

Table 1

Per cent chemical composition of the components of the experimental rations (on dry matter basis)

Constituents	Ration I				Ration II			
	Wheat bhusa	Para grass	G. N. cake	Maize grain	Paddy straw	Para grass	G. N. cake	Maize grain
Crude protein	2·39	6·57	48·16	10·07	3·60	6·49	46·18	9·97
Ether extract	1·59	2·18	6·28	3·71	1·67	2·55	6·12	4·14
Crude fibre	43·24	32·48	6·93	1·42	33·63	30·92	7·02	2·81
Nitrogen-free Extract	42·14	44·95	32·27	82·72	42·21	47·21	34·15	80·99
Total Carbohydrates	85·38	77·43	39·20	84·14	75·84	78·13	41·17	83·80
Total ash	10·64	13·82	6·36	2·08	18·89	12·83	6·53	2·09
Calcium (Ca)	0·17	0·33	0·15	0·08	0·46	0·40	0·16	0·09
Phosphorus (P)	0·09	0·31	0·73	0·33	0·09	0·32	0·76	0·36
Sulphur (S)	0·15	0·20	0·34	0·10	0·13	0·19	0·36	0·10
Oxalic acid	Nil	...	...	...	1·69	...	...	...

The oxalic acid content of the paddy straw used in this experiment was comparable to that reported by Talapatra et al. (1948b) and Warth et al. (1935) who have also reported the similar sulphur content in paddy straw (0·102 per cent).

PALATABILITY OF THE RATIONS AS JUDGED BY DRY MATTER CONSUMPTION BY THE ANIMALS DURING THE TRIAL PERIOD

With a view to compare the palatability of the two experimental rations, the dry matter consumption by experimental rams was recorded. The relevant data are given in table. 2.

TABLE 2

Dry matter consumption during the trial period

Animal No.	Dry Matter consumption/day/50 kg. body weight (kg.) Rations I	Dry Matter consumption/day/50 kg. body weight (kg.) Rations II	Calculated 't' value
2.	1·52	1·70	0·148*
3.	1·51	1·38	
5.	1·31	1·25	
6.	1·45	1·36	
7.	1·54	1·70	
11.	1·48	1·54	
Average	1·47±0·08	1·49±0·11	

* Insignificant.

It may be seen from the data presented in table 2 that dry matter consumption per day/50 kg. body weight by the rams was 1·47±0·08 and 1·49±0·11 kg. under ration I and II respectively.

The data were analysed statistically and difference in the consumption of dry matter by rams for the two rations was found to be insignificant. It shows that there is no difference in the palatability of the two rations with wheat *bhusa* and paddy straw as the basic roughages.

DIGESTIBILITY COEFFICIENTS OF THE ORGANIC NUTRIENTS

The average digestibility coefficients of the organic nutrients of the two experimental rations along with their standard errors and calculated 't' values have been given in table 3.

TABLE 3

Average digestibility coefficients of the organic nutrients (per cent)

Organic nutrients	Ration I	Ration II	Calculated 't' value
Dry Matter	54·65±0·79	54·42±1·35	0·14*
Crude protein	62·76±1·14	64·12±2·51	0·49*
Ether extract	72·86±0·80	74·88±1·42	1·21*
Crude fibre	54·61±1·26	58·70±1·11	2·43*
Nitrogen-free extract	59·84±0·53	57·13±1·38	1·50*
Total Carbohydrates	58·14±0·31	57·78±1·34	0·26*

* Insignificant.

It may be seen from the data (Table 3) that the differences in the digestibility coefficients of the dry matter and organic nutrients of the two rations are statistically insignificant. It indicates that the organic nutrients from both the rations were equally digested.

BALANCES OF NITROGEN, CALCIUM, PHOSPHORUS AND SULPHUR

The metabolic studies were conducted with a view to judge the utilisation of nitrogen, calcium, phosphorus and sulphur under the influence of two types of rations, as mentioned elsewhere. The relevant data for the balances have been recorded in table 5 along with their standard errors and calculated 't' values.

TABLE 4

The average actual intakes and balances for nitrogen, calcium, phosphorus and sulphur (gm.)

Particulars	Ration I		Ration II		Calculated 't' value for	
	Intake	Balance	Intake	Balance	Intake	Balance
Nitrogen	10·38±0·52	+2·73±0·56	12·34±1·25	+2·43±0·20	1·44*	0·50*
Calcium (Ca)	1·41±0·04	+0·17±0·09	3·06±0·31	−0·85±0·10	5·15**	7·55**
Phosphorus (P)	1·58±0·03	+0·09±0·003	1·91±0·06	−0·52±0·20	4·71**	3·05***
Sulphur (S)	1·24±0·03	+0·20±0·08	1·33±0·09	−0·09±0·08	1·00*	1·36*

* Insignificant.
** Significant (P<0·01).
*** Significant (P<0·05).

The data in table 5 indicate that the balances of introgen for ration I and II were 2·73±0·56 and 2·43×0·20gm/head/day respectively (Fig. I). The differences in the nitrogen intakes and balances for both the rations have been statistically found to be insignificant.

The respective balances for calcium and phosphorus were +0·17±0·09 and +0·09±0·003 gm/head/day under ration I and −0·85±0·10 and −0.52 ±0.20gm/head/day under ration II (Figs. 2 and 3). The differences in calcium and phosphorus intakes as well as balances under the two rations have been statistically analysed. The differences for calcium are singificant at 1 per cent for both the rations while for phosphorus, the intake difference is significant at 1 per cent and the balances at 5 per cent level of probability.

It is clear from the data (Table 5) that even with 3·06±0·03 gm. calcium ingestion in ration II, where paddy straw is the basic roughage, the animals on an average have shown a negative utilisation of −0·85±0·10 gm/head/day. On the other hand under ration I, where wheat *bhusa* is the basic roughage, the animals have shown a positive balance of 0·17.+0·09gm/head/day with only 1·41±0 04 gm of calcium ingestion. Significantly higher ingestion of calcium in ration II is due to the high content of calcium in paddy straw.

When we consider the components of the two experimental rations and their utilisation, we find that paddy straw definitely has some elements interferring with the mineral utilisation. This hypothesis has earlier been reported by Carbery et al. (loc. cit.), Talapatra et al. (1942 and 1948b) and Morris et al. (1955). Similar to our results, Patel et al. (loc. cit.), while working with bullocks, have reported +0·2 and −5·3 gm. calcium (CaO) balance/head/day with the ingestion of 9·2 and 15·0 gm. calcium (CaO)/head/day under the sole feeding of wheat *bhusa* and paddy straw respectively.

The outgo of calcium/head/day in urine has been recorded to be 0·22±0·03 and 0·15±0·006 gm in ration I and II respectively. It is not much different. But when the daily faecal excretion of calcium is looked into, we find that 2·75 gm. more calcium is voided by an animal under ration II where paddy straw is the basic roughage. Obviously paddy straw produces a condition in the digestive tract which interferes with calcium absorption.

Talapatra et al. (loc. cit.) mentioned that presence of oxalic acid in paddy straw as potassium oxalate creates alkalosis in the abomasum. The degree of alkalosis would tend to diminish the HCl secretion as a result of which absorption of dietary calcium is greatly diminished. Thus, the negative balances of calcium on paddy straw diet may be due to the alkalosis produced by the ingestion of oxalate. This hypothesis has also been confirmed by American Workers (Morris et al. loc.cit.) in vitro studies. In the present investigation, we have also found the oxalic acid content of paddy straw as 1·69 per cent whereas in wheat *bhusa* it is nil. Machanzie and McCollum (1937) have also shown that liberal consumption of feeds containing large amount of oxalates might cause an actual calcium deficit unless the diet contains generous amount of calcium.

In animal body, calcium and phosphorus have much in common in their occurence, functional behaviour and utilisation. The low utilisation of phosphorus in ration II may also be due to the alkaline condition of the abomasum, wherein phosphorus probably is not transferred into soluble form and thus passes in the faeces unabsorbed.

Under ration I, an average intake of 1·24±0·03 gm sulphur gave a positive balance of 0·20±0·08 gm and under ration II an average intake of 1·33±0·09 gm of sulphur gave a negative balance of 0·09±0·08 gm (Fig. 4). But this difference has statistically been found to be insignificant. Two animals on the same paddy straw ration have also shown the positive balance for this element.

The Average Daily Intake of the Digestible and Mineral Nutrients from each Ration by each Ram of Converted 50 kg. Live Weight as Compared to Morrison's Feeding Standard

For a comparative study, the daily actual intake of the digestible and mineral nutrients by each ram of varying body weight in both the trials, was converted to each ram of 50 kg. body weight. The calculated relevant data have been given in table 5 alongwith the nutrients requirements for 50 kg. ram according to Morrison's feeding standard.

Table 5

The average daily actual intake of the digestible and mineral nutrients from the two rations by each ram of 50 kg. body weight as compared to Morrison's standard.

Digestible and mineral nutrients	Actual Intake in kg. for organic nutrients and in gm. for minerals		Daily nutrients requirement for 50 kg. ram according to Morrison's feeding standard
	Rations		
	I	II	
D. C. P.	0·08±0·00	0·08±0·00	0·07–0·09 kg.
T. D. N.	0·83±0·20	0·79±0·03	0·77–0·95 kg.
Calcium (Ca)	2·83±0·05	5·34±0·36	4·0 gm.
Phosphorus (P)	3·19±0·03	3·41±0·09	3·2 gm.
Sulphur (S)	2·51±0·05	2·36±0·09	...

From the data presented in table 5, it is obvious that the animals under both the rations were virtually kept more or less in the same plane of nutrition, and intake is quite comparable to the Morrison's recommendations except for calcium. The calcium contents of wheat *bhusa* and paddy straw have affected the intake of this mineral from Ration I and II respectively.

On the basis of these findings it may be inferred that sheep under alkali producing diets should be provided with about thrice more calcium and roughly twice more phosphorus than those kept on acid producing diets.

SUMMARY

The aim of the present project was to determine whether there is any difference in the mineral utilisation under feeding of acid producing (wheat *bhusa*) and alkali producing (paddy straw) roughages.

Two metabolic trials were conducted one after the other on the same set of six 'Magra' rams, kept on ration I and II. The two rations differed in respect of roughage-wheat *bhusa* being the roughage in ration I and paddy straw in ration II.

In general the chemical composition of the various components of the two rations was comparable. Wheat *bhusa* did not contain an estimable amount of oxalic acid while paddy straw contained 1·69 per cent.

The palatability of ration I and II was equally good as is typified by 1·47±0·08 and 1·49±0·11 kg., drymatter intake/50 kg., body weight respectively.

The digestibility coefficients of dry matter, crude protein, ether extract, crude fibre, nitrogen-free extract and total carbohydrates have been found to be 54·65±0·79, 62·76±1·14, 72·80±0·8, 54·61±1·26, 59·84±0·53, 58·14±0·31 under ration I and 54·42±1·35, 62·12±2·51, 74·88±1·42, 58·70±1·11, 57·13±1·38 and 57·78±1·34 under ration II respectively. These values do not differ significantly.

The balances for nitrogen, calcium, phosphorus and sulphur were on an average +2·73±0·56, +0·17±0·09, +0·09±0·003 and +0·20±0·08 under ration I and +2·43±0·20, −0·85±0·10, −0·52±0·20 and −0·09±0.08 under ration II respectively. Even with higher intake of Ca and P, the paddy straw group showed negative balances.

D.C.P., T. D. N. and phosphorus intakes/50 kg., body weight of sheep are comparable with the recommendations of Morrison. Calcium, however, shows a different behaviour.

Judged from the above, the requirement of calcium (Ca) for sheep under alkali producing diets would be about thrice and that for phosphorus approximately twice as much as under acid producing diets.

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FIG. 1 - SHOWING NITROGEN INTAKES & BALANCES

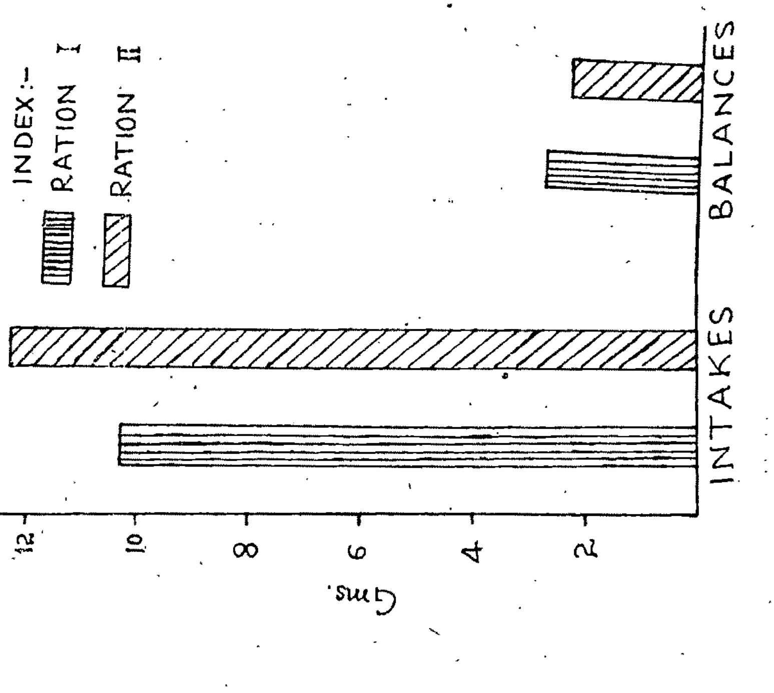


FIG. 2 SHOWING CALCIUM INTAKES & BALANCES

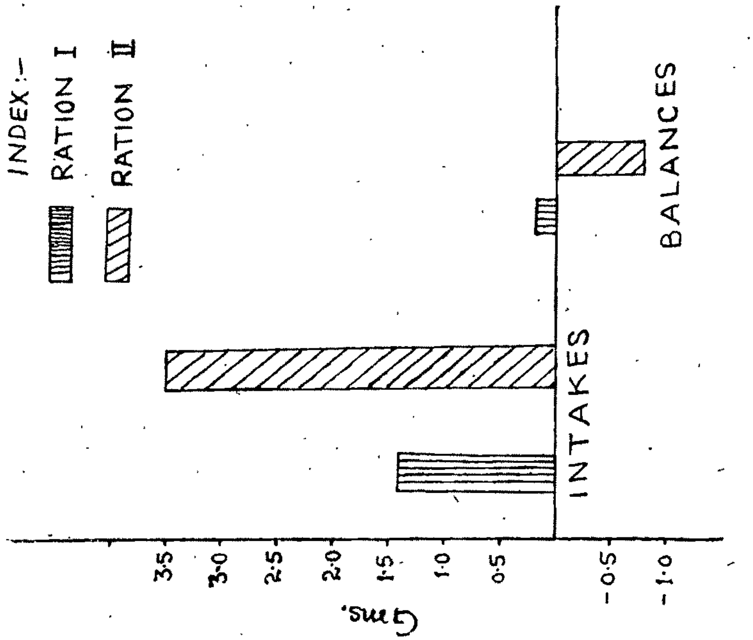


FIG. 3 SHOWING *PHOSPHORUS INTAKES* AND BALANCES

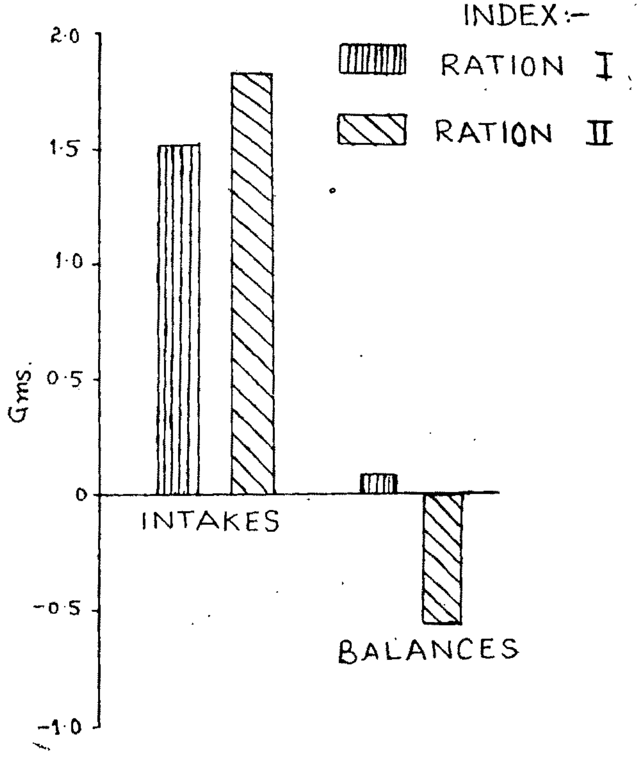
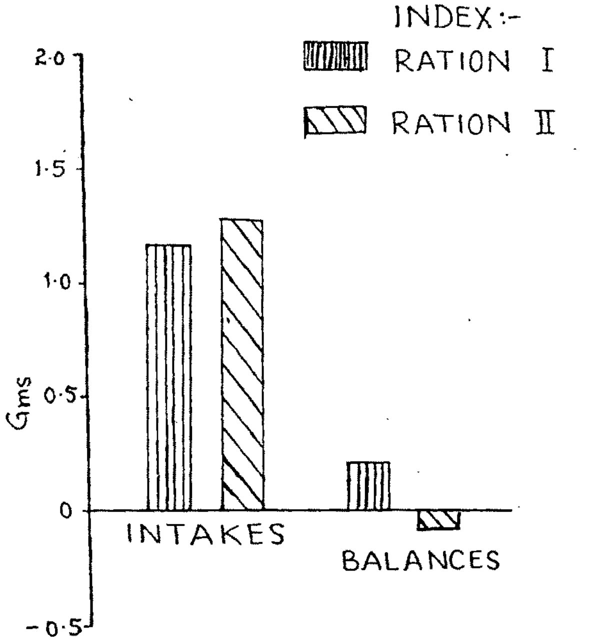


FIG. 4 SHOWING *SULPHUR INTAKES* AND BALANCES



LIGNIN AS AN INDICATOR IN DIGESTIBILITY DETERMINATIONS*

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Determination of the digestibility coefficients of various nutrients by the conventional method, which necessitates a total collection of faeces voided, is cumbersome, laborious and expensive. In order to simplify this time-honoured but laborious procedure, various methods have been suggested from time to time. One of these methods involves the use of certain physiologically and chemically inert materials (Lignin, Chromium oxide, Chromogens etc.) to serve as indices of digestibilities. Digestibilities are calculated from the ratios of the nutrients and the inert index material in the feed and in the resulting faeces according to the formula :

$$\text{Digestibility} = 100\text{-}100\left(\frac{\%\text{indicator in feed}}{\%\text{indicator in faeces}} \times \frac{\%\text{nutrient in faeces}}{\%\text{nutrient in feed}}\right)$$

The need for making total collection of faeces is thus eliminated as the digestibilities can be calculated from a single representative faecal sample. However, in view of the variations observed in the excretion rate of various indicators, one faecal sample would be insufficient for making accurate estimates of digestibilities. Attempts, in this study, were made to obtain maximum information regarding the accuracy and validity of one such indicator (Lignin) when used in the determination of digestibility coefficients.

EXPERIMENTAL PROCEDURE

A digestion trial on six adult Kumaoni bullocks was conducted in these investigations. The animals were offered a ration consisting of wheat straw and a concentrate mixture (wheat bran, barley, and linseed cake). A 15-days pre-experimental period was followed by a total collection period of 7 days. With a view to assess the magnitude of variations in the excretion rate of Lignin, the trial was extended by a period of 3 days during which faecal collections were made at every 3 hour intervals (8 grab-samples per day) and analysed for Lignin and dry matter.

Methods of chemical analysis followed in these investigations are essentially the same as recommended by the A.O.A.C. (1955). Various methods followed by earlier workers for the analysis of Lignin were reviewed and one used by Ellis *et al* (1946) being more reliable and practicable was adopted.

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* The data presented were taken from the thesis submitted by the senior author for the M.V.Sc. degree of the Agra University.

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RESULTS AND DISCUSSION

Lignin Recovery Test :

The recovery test for Lignin conducted by analysing the faecal samples secured from the total collection, showed that it is possible to obtain almost complete recovery in faeces of the ingested amounts of the indicator. The average recovery was 101·19±2·75 per cent of the amount ingested, which was considered satisfactory.

Digestibility coefficients (Conventional vs Lignin ratio method) :

Coefficients of 52·52±1·76 (dry matter); 59·36±2·93 (crude protein); 67·23±5·26 (ether extract); 57·22±2·13 (crude fibre); 55·37±2·51 (nitrogen-free-extract) and of 56·23±2·06 (total carbohydrates) obtained by the Conventional method and of 53·16±2·02 (dry matter); 59·94±3·17 (crude protein); 67·54±5·38 (ether extract); 57·82±2·12 (crude fibre); 55·99±2·59 (nitrogen-free-extract) and of 56·82±2·10 (total carbohydrates) obtained by the Lignin ratio method are, as is evident, in close agreement. Statistical analysis showed no significant differences, between the two sets of data, for any of the nutrients. It may be mentioned here that these determinations were made by analysing faecal samples secured from the total collection.

Diurnal variations in Lignin excretion :

Although errors, due solely to the method of determining digestibilities where Lignin is used as an indicator, have been proved to be insignificant, errors due to sampling method still remained to be solved. As indicated under experimental procedure, to study the magnitude of these errors, the trial was extended by a period of 3 days. Faecal samples were obtained directly from the rectum (grab-samples) and analysed for Lignin concentration.

The data representing such analyses showed a significant intraday and interday variations, although not so statistically, in the excretion rate of Lignin. These variations are considerably reduced when means of 3 days Lignin concentration in grab-samples obtained at particular hour on each day are considered. This can be examplified by comparing the digestibility coefficients for dry matter determined by the Conventional method (52·52) with those determined by the Lignin ratio method (53·71, 53·00, 53·46, 54·23, 54·65, 54·03, 52·35, and 55·38) by analysing 3 day's pooled grab-samples secured at 3 hour intervals starting from 1 o'clock in the afternoon.

A further study of the feed/faecal ratios (as substituted in the formula indicated on page 1) of Lignin concentration in 8 grab-samples (first day), again shows that although these ratios differ considerably amongst themselves, their means (0·467, 0·436, 0·506, 0·449, 0·477, 0·452) agree closely with similar ratios (0·471, 0.0·465, 0·452, 0·459, 0·506, 0·457) obtained by the Conventional method, for the six experimental animals respectively.

These studies confirm the findings in the literature that more than one faecal samples obtained at different hours on each day and composited for a large number of days may yield a representative sample which would accomodate both, the diurnal variations in the excretion rate of Lignin and the normally occuring variations in the excretion rate of nutrients, and thus permit the use of Lignin ratio technique in digestibility determinations.

ACKNOWLEDGEMENTS

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COLOUR CHANGES IN THE UNCATALYSED AND Ag^+ CATALYSED OXIDATION OF PHENOLIC COMPOUNDS BY PERSULPHATE ION

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INTRODUCTION

During the course of a systematic study of the kinetics of oxidation of phenolic compounds by persulphate ion, it was observed by us that these compounds either give coloured solutions or coloured precipitates on oxidation and that the colour of the solution or of the precipitate obtained in the uncatalysed reaction is sometimes different from that in the Ag^+ catalysed reaction. Hence it was thought by us that these reactions, under suitable conditions, may be used as a method of identification for some of these phenolic compounds. With this end in view, the colour changes on the addition of $K_2S_2O_8$ solution to the aqueous solution of a number of phenolic compounds, in cold and in hot water, both in the absence and in the presence of $AgNO_3$ solution as a catalyst, were studied.

EXPERIMENTAL

Potassium persulphate of G.R., E. Merck quality and silver nitrate of A.R., B.D.H. quality have been used. All the organic compounds studied were either of C.P. quality or L.R., B.D.H. quality. 1 ml. of an aqueous solution of the organic compound (about 2% by weight) was taken in a test tube and 2 ml. of 0·1 M $K_2S_2O_8$ solution was added. For the Ag^+ catalysed oxidation 0·5 ml. of 0·5% $AgNO_3$ solution was added after the addition of $K_2S_2O_8$ solution to the solution of the organic compound. These test tubes were allowed to stand at room temperature for 1-2 minutes for colour change or precipitate formation. Since in the case of many phenolic compounds there is no perceptible change in cold, another set of experiments were carried out for the uncatalysed as well as Ag^+ catalysed oxidation in hot water bath and the changes obtained within 2 minutes were noted.

OBSERVATIONS

The colour changes observed with different phenolic compounds for the uncatalysed and Ag^+ catalysed reactions are tabulated below :

TABLE 1

*R.T.—Room Temperature
†H.B.—Hot water bath

Organic compound	*Observations for the uncatalysed oxidation*	*Observations for the Ag^+ ion catalysed oxidation.*
Phenol M.P. 42°	No colour change at R.T.*, but changes to light yellow on keeping in H.B.† finally changes to brown precipitate.	Colourless solution, changes into yellow at R.T. On H.B. brown precipitate, finally blackish brown precipitate.

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TABLE 1 (*Contd.*)

Organic compound	*Observations for the uncatalysed oxidation*	*Observations for the Ag^+ ion catalysed oxidation*
Resorcinol M.P. 118°	No change at R.T., colourless solution changes into yellow solution in H.B.	No change at R.T., yellow solution in H.B.
Phloroglucinol M.P. 218°	No change at R.T. Slight yellow in H.B.	No change at R.T. Deep yellow solution in H.B.
Pyrogallol M.P. 133°	Changes into pink or reddish solution at R.T. In H.B. deep red solution or precipitate.	Pink or reddish solution at R.T. Deep red solution or precipitate in H.B.
Hydroquinone M.P. 53°	No perceptible change at R.T. Reddish yellow solution in H.B. On standing dark green needle like crystals of quinhydrone separate out.	No change at R.T. Reddish yellow solution in H.B.—On standing dark green needle like crystals of quinhydrone separate out.
Catechol M.P. 104°	Slight yellow colour at R.T. Deep red solution and finally brownish black precipitate on H.B.	Yellow colour at R.T. Deep red solution changing into reddish brown precipitate on H.B.
p-cresol M.P. 35°	No change at R.T., white gelatinous precipitate on H.B.	No change at R.T. On H.B. white precipitate in about 1 minute time, changing to yellowish white.
m-cresol B.P. 202°	No change at R.T. Dirty white precipitate on H.B.	No change at R.T. On H.B. dirty orange precipitate.
o-cresol M.P. 31°	No change at R.T. but light yellow solution immediately on H.B.—yellowish brown and finally black precipitate (granular)	Yellow solution at room temperature almost immediately on mixing. On H.B. dirty yellow solution, finally blackish brown or black precipitate.
Eugenol B.P. 247°	No change at R.T. Yellow solution changing into orange precipitate on H.B.	No change at R.T. Yellow solution changing into orange precipitate on H.B.
Thymol M.P. 50°	No change at R.T. White turbidity in hot.	Slight white turbidity at R.T. Yellowish white gelatinous precipitate on H.B.
o-Aminophenol M.P. 170°	No perceptible change at R.T. Yellow colour in hot.	Reddish violet solution at R.T. Brown precipitate on H.B.
m-Aminophenol M.P. 122°-123°	No change at R.T. On H.B. black brown precipitate	Very slight change in colour at R.T. Dark brown or black brown precipitate on H.B.
p-Aminophenol M.P. 184°	No change at R.T. but changes to light yellow on H.B.	No change in cold, changes to pink and then light yellow colour on H.B.

TABLE 1 (*Contd.*)

Organic compound	*Observations for the uncatalysed oxidation*	*Observation for the Ag+ ion catalysed oxidation*
p-chlorophenol B.P. 175°	No change at R.T. Yellowish white turbidity on H.B.	No change at R.T. Buff coloured precipitate on H.B.
o-chlorophenol B.P. 175°	No change in cold, changes to yellow on H.B. and finally light reddish precipitate or solution	Yellow solution at R.T. deepens on H.B., changes to reddish to brown precipitate.
o-Nitrophenol M.P. 44°	O.S. yellow, the yellow colour disappears on the addition of $K_2S_2O_8$, changes to slight yellow precipitate on heating.	Changes to yellowish orange precipitate on H.B.
p-Nitrophenol M.P. 114°	Yellow colour disappears on the addition of $K_2S_2O_8$ solution, but changes into white turbidity on H.B., finally yellowish white turbidity.	Gelatinous white precipitate on H.B.
m-Nitrophenol M.P. 97°	O.S. yellow-yellow colour disappears on the addition of $K_2S_2O_8$ changes to white with yellowish tinge turbidity on heating.	A white turbidity comes immediately on the addition of $AgNO_3$, changes to yellowish white precipitate on H.B.
2 : 4 Dinitrophenol M.P. 114°	At R.T. yellow colour disappears by the addition of $K_2S_2O_8$ solution and reappears on hot water bath.	Colour disappears at room temperature but reappears on standing or on heating.
2 : 4 : 6 Tribromophenol M.P. 95°	No change in colour either at R.T. or on H.B. But after some time a slight white precipitate settles.	White precipitate on H.B.
α-Naphthol M.P. 94°	No change at R.T. Light violet or dirty violet precipitate in hot.	A white opalescence in cold. Deep violet colour precipitate in hot.
β-Naphthol M.P. 122°	No change at R.T. white turbidity on H.B.	No change at R.T., but slight white turbidity. White turbidity on H.B. but disappears after some time.

It may be noted that the above observations about the colour changes are with pure compounds and, therefore, the melting point or boiling point given above refer to the pure compound.

On the basis of the above observations, we propose the following scheme of identification of some closely related phenolic compounds in the pure state.

A. *Solids :*

Phenol, resorcional, phloroglucinol, pyrogallol, hydroquinone, catechol, o- and p-cresols, thymol and *a* and *β* naphthol.

1. (a) To 1 ml. of an aqueous solution (about 2% by weight) of the organic compound add 2 ml. of 0·1 M solution of potassium persulphate at room temerature.

—pink or reddish pink solution in cold-pyrogallol.

—slight yellow solution changing to deep red solution on standing-catechol.

—No change in cold-phenol, resorcinol, phloro glucinol, hydroquinone, α and β -naphthols.

1. (b) Heat the above in hot water bath for about 2 minutes.

(*i*) Light yellow solution-phenol or phloroglucinol.
(ii) Yellow solution-resorcinol.
(iii) Reddish yellow solution-hydroquinone.

Derivative—To a hot saturated solution of hydroquinone, add a hot saturated solution of $K_2S_2O_8$ and after shaking for about 1-2 minutes, cool under ice-bottle green needle shaped crystals of quinhydrone separate.

(iv) Immediately yellow solution changing into yellowish brown precipitate-o-cresol.
(v) White gelatinous precipitate-p-cresol.
(vi) White or dirty white turbidity-Thymol or β-naphthol.
(vii) Light violet or violet precipitate-α-Naphthol.

To distinguish between phenol and phloroglucinol, thymol and naphthol carry out the test in presence of silver nitrate as catalyst as follows :

2. (a) To 1 ml. of an aqueous solution (about 2% by weight) of the organic compound add 2 ml. of 0·1 M $K_2S_2O_8$ solution and 0·5 ml. of a 0·5% silver nitrate solution and observe the change in cold :—

(i) No change in colour-phloroglucinol.
(ii) Yellow solution on standing at room temperature-phenol.
(iii) Slight white turbidity-β naphthol or thymol.

(b) Heat the above in hot water bath for about 2 minutes :—

(i) Deep yellow solution in hot-phloroglucinol.
(ii) Brown or blackish brown precipitate-phenol.
(iii) White turbidity-βnaphthol.
(iv) Yellowish white gelatinous precipitate-thymol.

B. *Liquids:* (m-cresol and eugenol.)

To 1 ml. of the aqueous solution add 2 ml. of 0·1 M $K_2S_2O_8$ solution and heat for 2 minutes in hot water bath.

(i) Dirty white precipitate-m. cresol.
(ii) Yellow solution changing into orange precipitate-eugenol.

C. *Aminophenols:*

To 1 ml. of the aqueous solution add 2 ml. of 0·1 M $K_2S_2O_8$ solution and heat for 2 minutes in hot water bath.

(i) Brown or blackish brown precipitate-m-aminophenol.
(ii) Light yellow solution-p-aminophenol.
(iii) Yellow solution-o-aminophenol.

To distinguish further between o- and p-aminophenols, perform the test in presence of $AgNO_3$ catalyst at room temperature :—

(i) Reddish violet solution-o-aminophenol.
(ii) No change in colour at room temperature but pink and then light yellow solution in hot -p-aminophenol.

D. *Nitrophenols:*

(a) To 1 ml. of the aqueous solution add 2 ml. of 0·1 M $K_2S_2O_8$ solution and heat for 2 minutes in hot water bath, (the yellow colour of the original solution of all the nitro-phenols studied except o-nitrophenol disappears on the addition of $K_2S_2O_8$ in cold).

  (i) Yellow solution changes into slight yellow precipitate-o-nitrophenol.
  (ii) White or yellowish white turbidity-m or p-nitrophenol.
  (iii) Yellow colour reappears-2 : 4 dinitrophenol.

(b) To distinguish further, perform the test in presence of $AgNO_3$ catalyst.

  (i) Yellowish orange precipitate in hot-o-nitrophenol.
  (ii) A white turbidity immediately on the addition of $AgNO_3$ in cold but gelatinous yellowish white precipitate in hot-m nitrophenol.
  (iii) Gelatinous white precipitate-p-nitrophenol.

As pointed out earlier the above scheme of identification is valid for compounds in the pure state and the presence of impurities or interfearing substances may require special consideration or modifications of the tests.

The identification of different products formed in these oxidation reactions is in progress. It is further proposed to study the absorption spectra of these coloured solutions to explore the possibility of using these reactions for the quantitative analysis of some of these compounds.

ACKNOWLEDGEMENT

One of us (K. C. Khulbe) is grateful to The Council of Scientific and Industrial Research, New Delhi for the award of Senior Research Fellowship to undertake this work.

STUDIES ON THE TELEOSTEAN HEART

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INTRODUCTION

The teleostean heart, although possessing many interesting structural features, has received little attention so far. Gegenbaur (1891) was the first to examine the heart of certain fishes and suggested the presence of a reduced conus in them. Smith (1918) and Parsons (1929) also made extensive studies on the conus arteriosus in teleosts but the general structure of the heart was neglected by them. Awati and Bal ('34), Wu and Liu ('44), Mott ('50), Prakash ('53), Karandikar and Thakur ('54), Nawar ('55) and Singh ('60) have made important contributions to our knowledge of the teleostean heart. The present study was undertaken to elucidate the structural variations and their functional significance in four species of teleosts.

MATERIAL AND METHOD

Live fishes were brought to the laboratory and made senseless by a mild stroke on the head. The heart was carefully exposed and removed to a petri dish containing saline water which was injected into the heart by means of a hypodermic syringe through the ductus cuvieri so as to clear it of the blood. The heart was then hardened in ten per cent formalin for 48 hrs, and thereafter dissected under a binocular microscope. Longitudinal, sagittal and transverse sections were cut and the observations were confirmed in three to six specimens.

The species examined are :

	Family	*Type.*
1.	Cyprinidae	*Tor tor* (Ham.)
2.	,,	*Orienus sinuatus* (Gunther)
3.	Siluridae	*Clarias batrachus* (Linn.)
4.	Notopteridae	*Notopterus notopterus* (Ham.)

STRUCTURE OF THE HEART OF *Tor tor* (Ham.)
(Plate I, Figs. 1 and 4.)

The heart lies within the pericardial sac anterior to the septum transversum and consists of four chambers the sinus venosus, auricle, ventricle and the bulbus arteriosus. The sinus venosus is a moderately large chamber and receives blood through the paired ducti cuvieri, a hepatic vein, a posterior cardinal, paired anterior cardinals and an inferior jugular vein. The sinus opens into the auricle through the sinu-auricular aperture guarded by a pair of membranous semi-lunar valves, each having a longer limb projecting into the auricle.

The auricle covers the ventricle in dorsal view and has an irregular outline. It is spongy in texture and has a narrow lumen extending upto the ventricle. The auriculo-ventricular opening is guarded by two pairs of semilunar valves of equal size. Each of these valves has a shorter limb attached to the wall of the auricle and a longer one adhering to the ventricular wall, its convexity projecting into the auricle.

The ventricle is a highly muscular chamber with thick walls and a narrow tubular passage in between. The ventriculo-bulbar opening is guarded by a pair of semi-lunar valves hanging into the lumen of the ventricle. Each has a shorter limb attached to the ventricular walls of its own side and a longer limb connected to the wall of the bulbus of the opposite side. Thus the longer limbs of the two valves cross each other. The bulbus too, has thickened walls and a narrow lumen. Its cavity is further obliterated due to the presence of several thin ribbon like trabeculae running parallel to each other. The bulbus arteriosus extends anteriorly as the ventral aorta.

Working—The venous blood continuously flowing towards the heart reaches the sinus venosus and passes into the auricle by pushing apart the semi-lunar valves. The blood fills the semi-lunar pockets of the valves also and the pressure due to the contraction of the auricle causes the valves to swell and adhere with each other, thus preventing the backward flow of the blood. The four auriculo-ventricular valves are arranged in a circle and are easily pushed apart by the blood which now flows from the auricle into the ventricle. As soon as the ventricular cavity is full, the valves also receive the blood. During the contraction of the ventricle, high pressure develops within it and the valves bulge out, their walls adhere and completely close the auriculo-ventricular opening. The blood, therefore, pushes aside the laterally placed ventriculo-bulbar valves and enters the bulbus. Again, the pressure inside the bulbus increases causing the valves to swell and close the passage preventing any backward flow of the blood during contraction. The blood is now forced into the ventral aorta.

STRUCTURE OF THE HEART OF *Orienus sinuatus* (Gunther)

(Plate I, Figs. 2 and 3.)

The heart of *O. sinuatus*, though resembling with that of *T. tor* described above, shows some interesting differences. The sinus venosus receives blood through the ducti cuvieri, two hepatic veins, a single posterior-cardinal, an inferior jugular and a pair of anterior cardinals. The auricle is relatively larger in size, almost triangular in shape, with the apex pointing posteriorly and the base showing a deep notch. A pair of membranous valves are present at the sinu-auricular aperture. The auricle is spongy but the auriculo-ventricular opening is guarded by one pair of semi-lunar valves only. The ventricle is highly muscular and the ventriculo-bulbar opening is provided with a pair of cup-shaped membranous valves. The tubular lumen of the bulbus has trabeculae as in *T. tor* and the mode of working of the different valves resembles in the two species.

STRUCTURE OF THE HEART OF *Clarias batrachus* (Linn.)

The heart of *Clarias batrachus* differs from that of *T. tor* described earlier in some important features. The sinus venosus is made up of semi-transparent wall and receives blood through the ducti cuvieri, paired anterior and posterior cardinals, a single inferior jugular vein, a hepatic vein and a pair of arborescent veins. The auricle has an irregular outline and is slightly shifted to the right. As usual, the auricle is spongy looking like a honey comb and the sinu-auricular aperture is guarded by a pair of valves which differ from those of the other fishes in being simple and flap-like disposed of dorso-ventrally on either side of the opening. The auricle has a tubular cavity extending from the sinu-auricular aperture to the auriculo-ventricular opening, the latter being guarded by a pair of equal sized semi-lunar valves, the second pair of smaller valves found in other related species being absent. The ventricle is highly muscular with thick walls so that its cavity is considerably reduced. It opens into the bulbus which is tubular with a swollen basal part. The walls of the bulbus are thin and its cavity is relatively wider, there being no trabeculae in it. The ventriculo-bulbar opening is guarded by means of a pair of membranous valves which are oval and pocket-shaped with their greater part lying in the ventricular lumen.

Working—The blood reaches the sinus venosus and passes forwards into the auricle. The sinu-auricular valves being merely a pair of flaps. They do not appear to be very efficient in checking the backward flow of the blood and exhibit a very simple type of arrangement. The auriculo-ventricular valves are, however, semi-lunar in shape and allow the blood to go ahead through between them, but a reverse current fills their cavities thus bringing their walls closer and blocking the passage. The ventriculo-bulbar valves have their longer limbs running parallel to each other. The blood pushes its way through the space between them but as the bulbus is full, the blood fills the pocket-shaped valves which due to high pressure developed inside the bulbus bulge in and check the backward flow by closing the passage. These valves appear to perform their function most efficiently.

STRUCTURE OF THE HEART OF *Notopterus notopterus* (Ham.)

(Plate II, Figs. 3 and 4.)

The heart of *N. notopterus* resembles with that of *N. chitala* (Singh '60). It is peculiar in being somewhat L-shaped in lateral view, possibly due to a flattened leaf-like body of the fish. The sinus venosus receives a pair of cuvierien ducts, paired inferior jugulars and a median hepatic vein. The sinu-auricular opening is guarded by five to seven nodular valves that are irregularly arranged. These are of varying size and presumably check the backward flow of the blood, as they are attached with the wall of the auricle by means of their thread like prolongations (chordae tendinae).

The auricle is spongy due to several pits of unequal size in its wall and has a narrow lumen extending from the sinu-auricular aperture to the auriculo-ventricular opening. This latter is guarded by a pair of equal sized semi-lunar valves. Each valve has a shorter and a longer limb, both of which are attached with the wall of its own side.

The ventricle itself is highly muscular with thick walls and a narrow lumen. In a transverse section, the ventricle is triangular due to a conical bulging on the ventral side. The ventriculo-bulbar opening is provided with a pair of ribbon-like valves which are in the form of a pair of vertical partitions so as to divide the bulbus into three chambers one median and two lateral. The proximal part of the bulbus is muscular and is embedded in the ventricle looking like a rudimentary conus in this species also as in *N. chitala* (Singh '60). The ribbon-like valves are joined to the bulbus along the dorsal and the ventral margins in the posterior two-third part, thus dividing the cavity completely into three chambers. In the anterior portion these partition valves are incomplete so that the three chambers communicate with each other, there appears to be no foramina in the valves as described for *N. chitala* (Singh '60).

Working—As mentioned above, the nodular valves at the sinu-auricular aperture are not very efficient and show a very much simplified type of arrangement. The semi-lunar auriculo-ventricular valves function as in the other teleosts. When the ventricle contracts, the blood moves forward through the central channel of the bulbus and as it reaches the anterior portion of the bulbus, flows out into the lateral chambers, due to the incomplete ribbon-like valves. As soon as the lateral tubes are full, the valves stick to each-other and close the central passage.

DISCUSSION

A study of the heart of the above mentioned four species of teleosts shows that a considerable variation and specialisation exists in them, especially in the valvular mechanism. A single sinu-auricular valve with two membranous flaps is present in *Tetrodon oblongus* (Awati and Bal 1934) while Prakash (1935) reported a single sinu-auricular valve in *Heteropneustes fossilis*. Mott (1950), has recorded three such valves that are asymmetrically placed in the eel, *Anguilla anguilla*. Singh ('60) on the other hand, describes a pair of semi-lunar sinu-auricular valves in a number of fishes. Of the species described here, a pair of semi-lunar valves are present in *Tor tor* and *O. sinuatus*. In *C. batrachus* these valves are much less efficient being a pair of membranous flaps, probably like those present in *Tetrodon oblongus* (Awati and Bal, 1934). The condition in *N. notopterus* is peculiar and only 5-7 nodule like structures are present in the neighbourhood of the sinu-auricular opening. This resembles closely with

N. chitala (Singh '60) where 8-10 nodular valves are present. It is, however, doubtful if these nodules are of any help to the fish.

Auriculo-ventricular valves are either two in number as in *O. sinuatus* and *C. batrachus* or four as in *Tor tor.* They are semi-lunar in shape and membranous and appear to perform their function efficiently irrespective of their number. The ventriculo-bulbar opening is guarded by a pair of valves that are semi-lunar in *T. tor* and *O. sinuatus,* but oval and pocket shaped in *C. batrachus* and long, ribbon-like in *N. notopterus.* In the last two species they are more specialised, partly to compensate for the less efficient and primitive type of sinu-auricular valves in them. The bulbus is thick walled in *T. tor* and *O. sinuatus* and the lumen is full of trabeculae but it is thin walled and without trabeculae in *C. batrachus.* The valves are so arranged as to allow the blood to flow towards the bulbus but prevent the backward passage. The sinus venosus has thin membranous walls in all the four species of fishes examined and is not 'fibrous and spongy' as found in *Labeo rohita* and *Cirrhina mrigala* (Singh, '60).

A definite conus arteriosus with four endocardial valves, is reported to be present in *Heteropneustis fossilis* (Prakash '53). Such a well formed conus is absent in the species described here and only a rudimentary type of conus is present in *N. notopterus.*

SUMMARY

1. The structure and working of the heart of four teleostean fishes has been described.

2. The generalised condition of the heart is exhibited by *Tor tor* but several variations and peculiarities exist in the other species.

3. The sinus venosus is thin walled, auricle is spongy, ventricle thick-walled and muscular and the bulbus has either thin or thick walls.

4. There are two semi-lunar sinu-auricular valves in *T. tor* and *O. sinuatus* but these are much simplified in *C. batrachus* and in the form of peculiar nodules in *N. notopterus.*

5. The ventriculo-bulbar valves are either two or four in number and specialised in *C. batrachus* and *N. notopterus,* presumably to compensate for the less efficient sinu-auricular valves in them.

6. Only rudimentary conus exists in *N. notopterus.*

ACKNOWLEDGEMENT

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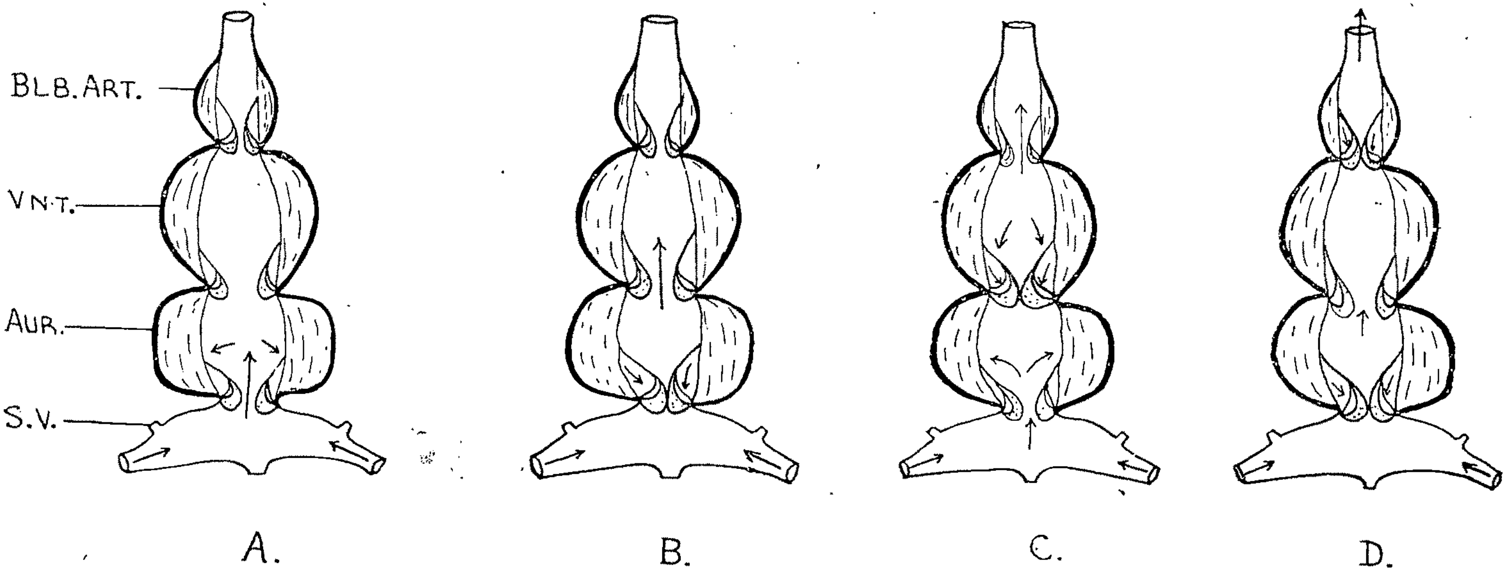
ABBREVIATIONS

AUR. — Auricle.
AUR. LUM. — Auricular lumen.
AUR.VET.VL. — Auriculo-ventricular valve.
BLB.ART. — Bulbus arteriosus.
CN.ART. — Conus arteriosus.
DT.CV. — Ductus Cuvieri.
FRC. — Incomplete ventriculo-bulbar valves.
HPT.VN. — Hepatic vein.
INF.JG.VN. — Inferior jugular vein.
PS.CD.VN. — Posterior Cardinal vein.
S.V. — Sinus venosus.
SIN.AUR.VL. — Sinu-auricular valve.
TRB. — Trabeculae.
V.A. — Ventral aorta.
VNT. — Ventricle.
VNT.LUM. — Ventricular lumen.
VNT.BLB.VL. — Ventriculo-bulbar valve.



Text - Figure.1.

Schematic drawings to show the valvular mechanism of a typical teleostean heart.

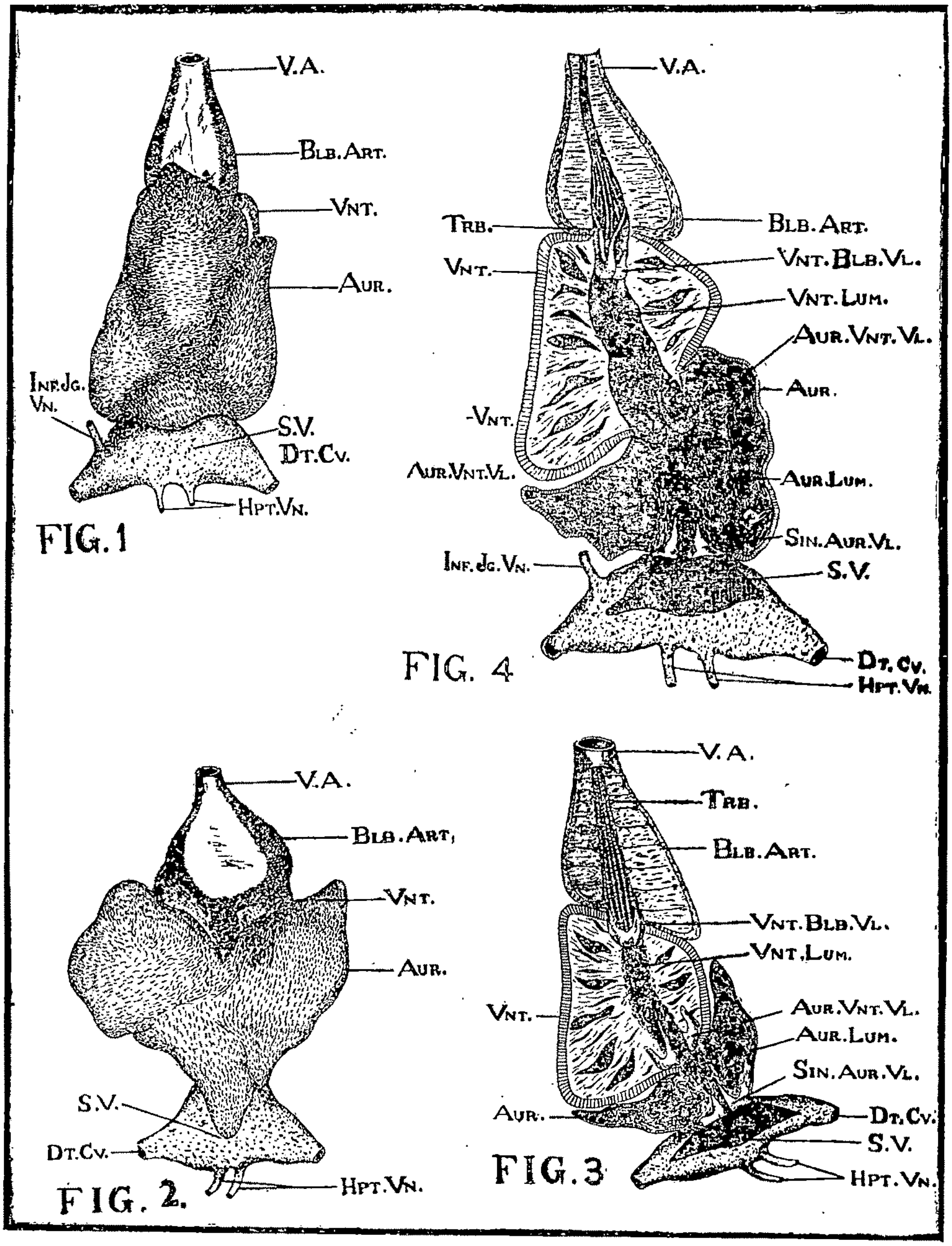


PLATE I

Fig. 1.	Dorsal view of the heart of *Tor tor*	x4
Fig. 2.	Dorsal view of the heart of *Orienus sinuatus*	x4
Fig. 3.	Dissection of the heart of *O. sinuatus* from the lateral side	x4
Fig. 4.	Dissection of the heart of *T. tor* showing the internal structure	x6

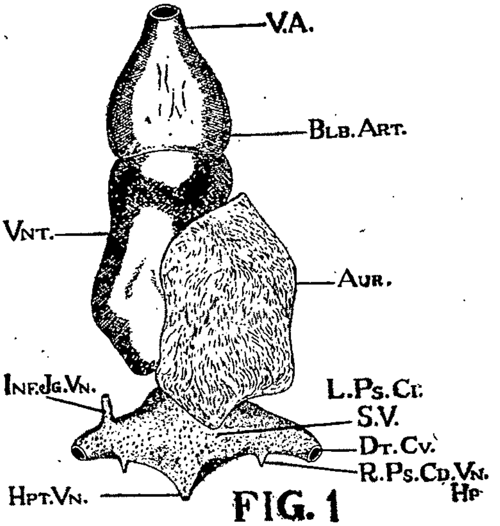


FIG. 1

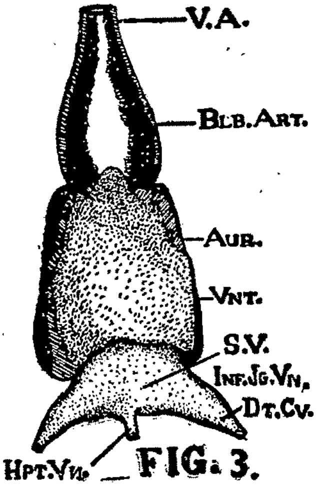


FIG. 3.

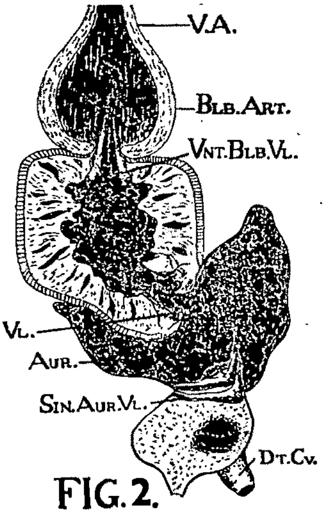


FIG. 2.

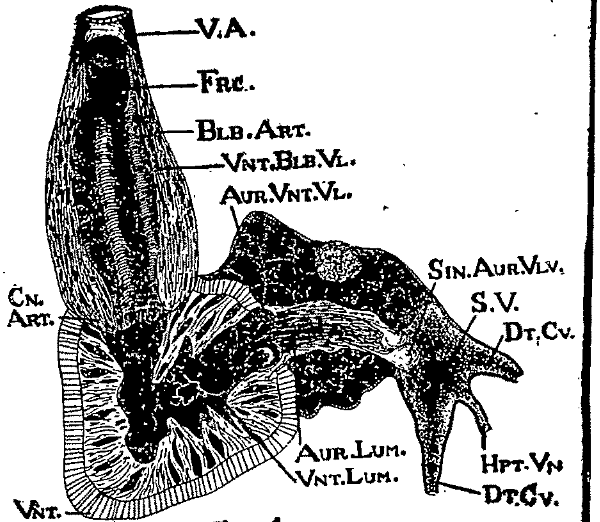


FIG. 4

PLATE II

Fig. 1.	Dorsal view of the heart of *Clarias batrachus*	x4
Fig. 2.	Median longitudinal section of the heart of *C. batrachus*	x4
Fig. 3.	Dorsal view of the heart of *Notopterus notopterus*	x4
Fig. 4.	Median longitudinal section of the heart of *N. notopterus*	x6

Abstract of Theses

NOTES ON FOUR GENERA OF THE TREMATODE PARASITES OF INDIAN DOMESTIC DUCK*

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While reporting the parasites of domestic duck (*Anas boschas domesticus* L.) in Madras, Lalitha and Alwar (1960) have referred to the occurrence of ten species of trematodes : *Pancreatrema* sp; *Opisthorchis obsequens* Nicoll, 1914; *O. desouzai*, n.sp. (without any description or diagnosis); *Echinostoma revolutum* (Fröhlich, 1802); *Psilochasmus longicirratus* Skrjabin, 1913; *Prosthogonimus* sp; *Notocotylus attenuatus* (Rudolphi, 1809); *Transcoelum oculeum* (Kossack, 1911); *Cotylurus japonicus* Ishii, 1932 and *Trichobilharizia rodhaini* Fain, 1955. In a later publication, Alwar and Lalitha (1961) have designated *O. desouzai*, *P. longicirratus* and *C. japonicus* as *Opisthorchis* sp; *Psilochasmus* sp; and *Cotylurus* sp. respectively. They have further identified the unnamed species of the genus *Prosthogonimus* (op. cit.) as *P. cuneatus* and *P. skrjabini*, and have also added another species, *Tracheophilus cymbius* to the list.

During a survey of the common helminth parasites of domestic birds, the collection, made locally by one of us (D.N.) during 1961 from *Anas platyrhynchos domesticus* yielded the following four species of trematodes : *Typhlocoelum cucumerinum* (Rudolphi, 1809) : (Cyclocoelidae); *Catatropis indicus* Srivastava (Notocotylidae); *Opisthorchis obsequens* Nicoll, 1914 (Opisthorchiidae) and *Psilochasmus oxyurus* (Creplin, 1815) Lühe, 1909 (Psilostomidae). An account of these species is given hereunder as considerable variations have been noticed which are not found in available descriptions.

Typhlocoelum cucumerinum (Fig. 1)

One of the ducks harboured, in its trachea, three specimens of this species, one mature and two immature. One of these was serially sectioned and stained. This form had been previously found in an unidentified wild duck by one of us (B.P.P.).

Ventrally the cuticle has well developed papillae and distinct, saccular, unicellular glands with median ducts (Fig. 11). These specimens also exhibit some variations in testicular contour which is, however, slight in immature specimens (Fig. 2). In one specimen both the testes are deeply lobed and the anterior one is situated at the level of the ovary (Fig. 3). In another specimen, the anterior testis is somewhat quadrangular and is slightly lobed (Fig. 4). In the third specimen both the testes are nearly oval and uniform. The anterior testis is situated at the level of ovary. These three specimens have few uterine loops between the two testes. In younger specimens, the ovary also shows variations in its position in relation to the anterior testis.

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* Part of the Thesis for the award of M.V.Sc. degree (1961) of Agra University to D.N.

Bisseru (1957) has considered *Tracheophilus* Skrjabin, *Typhlutimum* Witenberg, 1926, and *Typhlophilus* Lal, 1936 as synonyms of *Typhlocoelum* of which he has given an emended diagnosis, and has also regarded *Typhlocoelum americanum* Manter & Williams, 1928 and *T. shovellus* Lal as synonyms of *T. cucumerinum.* Yamaguti (1958) has, however, recognised the genera *Typhlocoelum, Tracheophilus,* and *Typhlophilus,* and has considered *Typhlophilus obovale* and *T. reticulare* as synonyms of *T. cucumerinum.*

The present material exhibits a degree of lobulation which intergrades between these two conditions and, therefore, invalidates the separate indentities of *T. cymbius* & *T. cucumerinum* which embraces the former as its junior synonym. Macko & Busa (1960) have also concluded likewise and have recorded long range variations in the characters of *T. cucumerinum.*

Catatropis indicus (Fig. 6)

Two specimens of this species, already reported from domestic fowl in this country, were recovered from one of the ducks autopsied. These conform in general with the description given by Srivastava (1955). One of these was stained and mounted and the other serially cut and stained.

In these specimens the cuticle is beset ventrally with minute cuticular spines which become sparce posteriorly. The ventral papillae (Fig. 8) are in two lateral rows, 12 in one and 13 in the other, with the first and the last of the papillae in both rows being distinctly smaller than the others (Fig. 7). The median glandular ridge is richly supplied with unicellular glands which open in small depressions on the ventral surface (Fig. 9) and extend medially from the anterior border of the ovary to the base of the cirrus sac.

Thirteen species have been listed by Skrjabin (1953) under *Catatropis* but Yamaguti (1958) has recognised only twelve including the two Indian species, *C. indicus* Srivastava, 1935 and *C. orientalis* Harshe, 1932. The third species, also described from India, *C. rauschi* Singh, 1956 has not been mentioned by Yamaguti (l.c.). *Catatropis verrucosae* (Frohlich, 1769) is also recorded from the domestic ducks of Madras (Ramanujachari & Alwar, 1952) and is known to occur, both in wild and domestic ducks of Europe, Asia and Africa.

A few minor differences with regard to size of body, number of papillae in the lateral rows, length of oesophagus, length and structure of cirrus sac, size of ovary and shell glands were, however, observed. No reference to the presence of an internal seminal vesicle is found in the description or diagrams of this species. Lal (1939) had questioned the inclusion of *C. orientalis* and *C. indicus* under *Catatropis* as, in his opinion, details regarding the ventral glands, whether protrusible or nonprotrusible, were not available, and in the latter the genital pore was comparatively anterior in position. *Catatropis,* accor ding to Lal, was to include only forms with the genital pore situated behind the intestinal bifurcation. Harwood (1939), however, recognised both these species and believed that characters of value in differentiating the various forms could be : shape of the body, presence of mid-ventral keel, position of genital pore (whether anterior to, or behind the intestinal bifurcation), posterior extent of the cirrus sac, the anterior extent of the uterine loops in relation to the cirrus sac, the extent of the vitelline follicles in relation to the middle loops of the uterus, extent of the lateral papillae, length of the cirrus sac in proportion to the total body length and length of the oesophagus in relation to the oral sucker.

The ventral glands or papillae and the glandular ridge or keel in some of the monostomes have been differently interpreted. In a series of stained sections available, these lateral structures occur in the form of normally protruded papillae without any glandular character (Fig. 8). The midventral ridge, on the other hand, is definitely glandular (Fig. 9). Srivastava (1935) and Lal (1939) have considered these glands as nonprotrusible, whereas, according to Singh (1956), they may or may not be protrusible. Smith (1954) did not observe any pores on the papillae which were non-glandular. In *C. rauschi* the two lateral rows of glands were described as protruded, whereas in the middle row, they formed a ridge. The sections of *C. indicus* studied show the ventral surface with the two rows of protruded papillae and the mid-ventral ridge carrying all over a large number of unicellular glands with long ducts. In *T. cucumerinum*, the ventral surface has protruded papillae with a concentration of gland cells lying between them. Martin (1956) had likewise observed this glandular character.

Opisthorchis obsequens (Fig. 12)

The single specimen available was identified as belonging to this species on account of the ratio between the two suckers, extent of intestinal caeca, shape of excretory bladder, position of genital pore, topography of genital organs, arrangement of uterine coils and size of the eggs. The vitelline follicles were, however, in continuous series.

Opisthorchis has numerous species described from fishes, reptiles, birds and mammals and a number of genera have been proposed to accommodate some of these forms. The question of validity of some of these species has been discussed in a revision of the genus by Bisseru (1957) who has listed the following species from Indian birds : *Opisthorchis dendriticus* Morgan, 1926; *O. cheelis* Lal, 1939; *O. giddhis* Lal, 1939; *O. indicus* Mehra, 1941 and *O. pelicani* Mehra, 1941 and has considered *O. allahabadi* Mehra, 1941 synonymous with *O. longissimus* (v. Linstow, 1883). Gupta and Pande (1963) have dealt with the species of this genus occuring in mammals.

Psilochasmus oxyurus (*Creplin*, 1815)
Syn : *P. longicirratus* Skrjabin, 1913

P. japonicus Ishii, 1935
P. alii Jaiswal, 1957
P. megacetabulous Jaiswal, 1957 (Fig. 13)

Three adult specimens were recovered from the small intestine of one of the ducks which also harboured *Typhlocoelum* infection. The well developed cirrus sac, saccular in its basal part, extended posteriorly beyond the ventral sucker upto the ovarian zone. In one specimen, in its posterior extent, it extended as far as the posterior border of the ovary and in another even beyond. In the sections studied, the posterior extent of cirrus sac was slightly anterior to the ovary.

The genus was first recorded from Indian birds by Inamdar & Bhalerao (1944) who reported *P. longicirratus* Skrjabin, 1913, from *Nyroca ferina*. Subsequently, Baugh (1947) and Singh (1954) recorded *P. oxyurus* from *Anas poecilorhynchus* and *Anas acuta* respectively. Stunkard and Dunihue (1931) have considered *P. longicirratus* as synonym of *P. oxyurus*. Inamdar & Bhalerao (1944) and Singh (1954) have agreed with this decision but Tubangui (1932) has considered the two species, *P. oxyurus* and *P. longicirratus* as valid. Other species which are synonymised with *P. oxyurus* are : *P. agilis Travassos,* 1926; *P. lecithosus* Otto, 1926; *P. japonicus* Ishii, 1935; *P. skrjabini* Gnedina, 1946; *P. alii* Jaiswal, 1957; and *P. megacetabulus* Jaiswal, 1957. Yamaguti (1958) has also listed *Hypodaerium conoidenum* (Bloch) as a synonym of *P. oxyurus*.

In the present material the cirrus sac, in its posterior extent, varies in position, being anterior to, or reaching near the middle or even behind the ovary. The vitellaria too, in their anterior extent, vary as follicles extend to the anterior level of the acetabulum or upto its middle. We endorse the views of Stunkard & Dunihue (l.c), Inamdar & Bhalerao (l.c) and Singh (l.c) in synonymising *P. longicirratus* with *P. oxyrus*. The length of the prepharynx depends naturally on the contraction undergone by the specimens during and after fixation and accordingly *P. agilis* is not tenable on this character and therefore appears identical with *P. oxyurus*. Thus, the remaining three species under this genus are : *P. japonicus*, *P. alii* and *P. megacetabulus*. In *P. japonicus*, the dimensions alone appear to have been given without any specific diagnosis. This form resembles *P. oxyurus* and according to Yamaguti (1958) is a synonym of *P. longicirratus* (*P. oxyurus*). Jaiswal (1957), considering *P. alii* as allied to *P. longicirratus*, differentiated his new species on account of the cirrus sac extending posteriorly to the level of anterior border of ovary, presence of a sharply marked off and hooked tail and the larger size of its eggs, and has ignored consideration of the observations made by previous workers on the posterior extent of the cirrus sac. According to Stunkard & Dunihue (1931), the tail has "a terminal spike projecting from a depression in the ventral surface at the caudal end". A prominently sharp tail has also been figured by Tubangui in *P. longicirratus*. Jaiswal (1957), for his species gives the size 110-130 × 68-73μ. In the range for measurements, as given by Stunkard & Dunihue (l.c.), Inamdar & Bhalerao (l.c.) and Singh (l.c.), the eggs, in size are 100-120

×70-77μ, 99-102×55-65μ and 89·7-110×52-70μ respectively and the limits indicated by Jaiswal come well within these ranges. *P. alii* is, therefore, suppressed as a synonym of *P. oxyurus*. *P. megacetabulus*, described by Jaiswal from a single specimen and stated to resemble *P. alii*, was differentiated on account of its different body measurements, longer oesophagus, ovary being widely separated from anterior testis, ratio of the sucker being 1 : 2·4, ventral sucker being just behind the intestinal bifurcation and the genital pore being ventral instead of lateral to intestinal bifurcation. Oesophageal length, position of ventral sucker in relation to intestinal bifurcation, relative position of ovary and anterior testis and the position of genital pore all depend greatly on the degree of contraction during fixation. The only character that remains, and, if present constantly, would be the sucker ratio but in the present case the variation is a minor one and can not warrant the separation of the specimen under a separate species. *P. megacetabulus*, therefore, is also suppressed as a synonym of *P. oxyurus*. *Psilochasmus skrjabini* is not taken into account as its detailed description is not available. *Psilochasmus longicirratus*, *P. japonicus*, *P. alii* and *P. megacetabulus* are all considered as synonyms of *P. oxyurus* which seems to be the only valid species of this genus.

SUMMARY

Typhlocoelum cucumerinum, *Catatropis indicus*, *Opisthorchis obsequens* and *Psilochasmus oxyurus* are recorded from the Indian domestic duck. *Psilochasmus longicirratus*, *P. japonicus*, *P. alii* and *P. megacetabulus* are considered as synonyms of *P. oxyurus*.

ACKNOWLEDGEMENTS

Thanks are due to Professor S. Boev of the Institute of Zoology, Alma Ata and Professor M.A. Basir, Aligarh Muslim University, Aligarh for the assistance in the matter of literature and to the Principal, U.P. College of Veterinary Science and Animal Husbandry, Mathura, for facilities provided.

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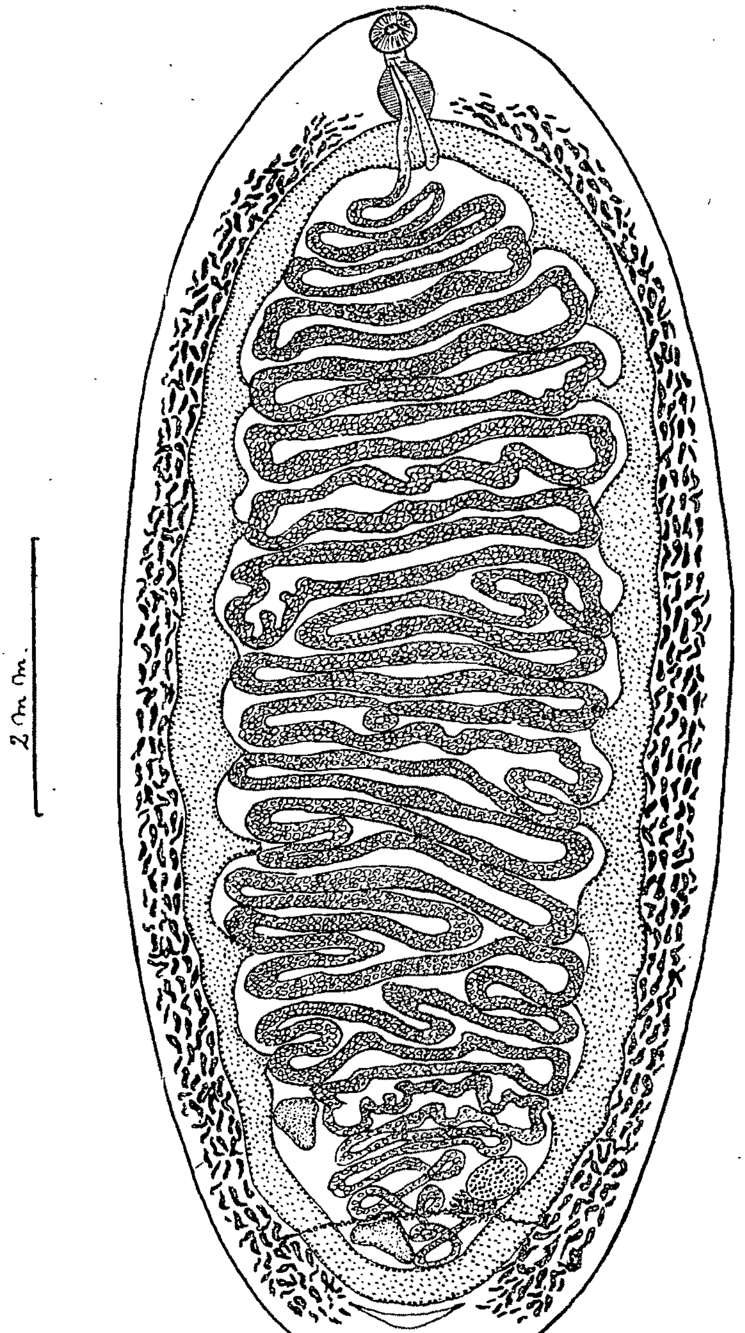

Fig. 1. *Typhlocoelum cucumerinum*, ventral view.

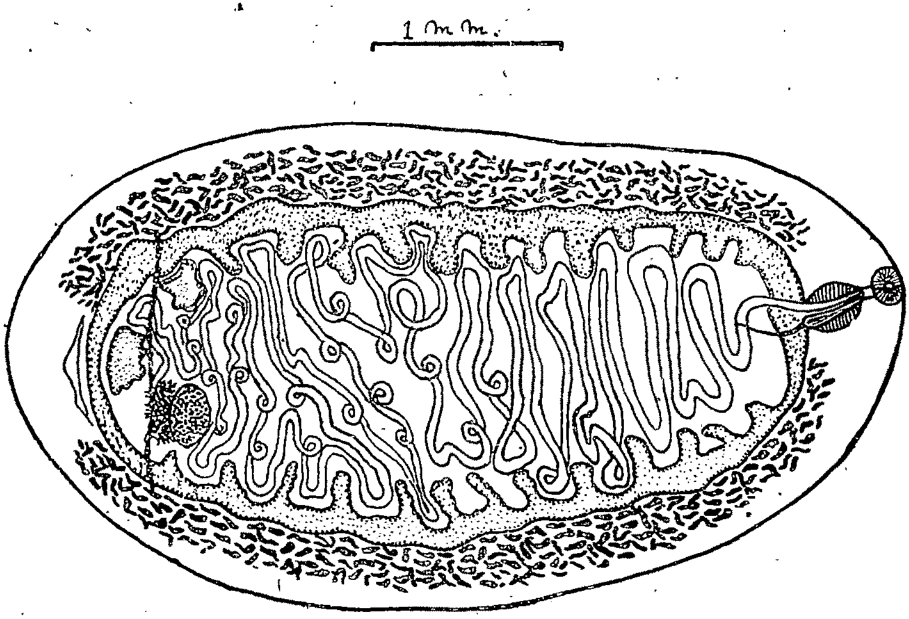

Fig. 2. *T. cucumerinum*, immature specimen, ventral view.

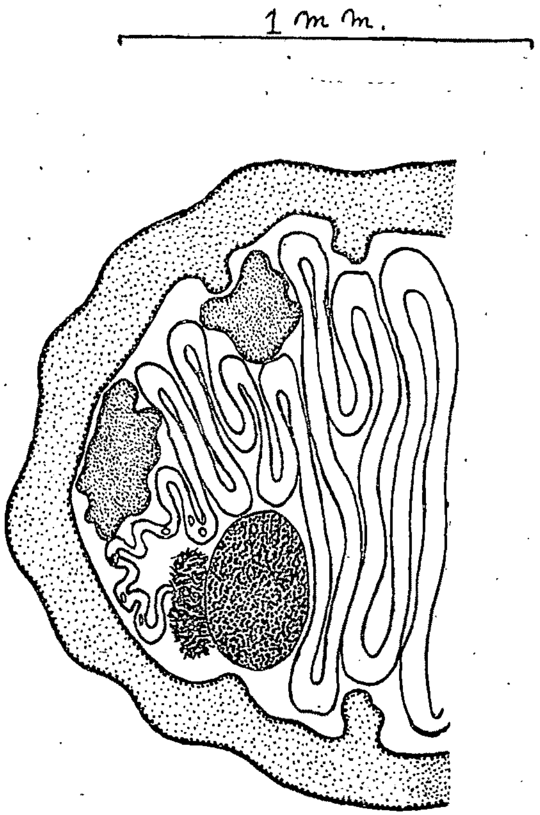

Fig. 3. *T. cucumerinum*, posterior region of immature specimen showing the lobed nature of both testes.

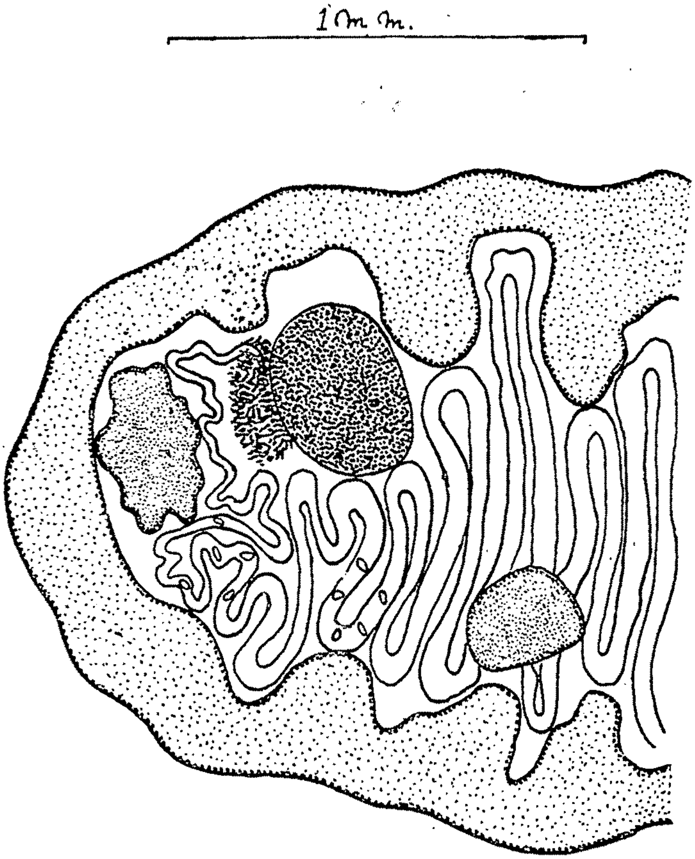

Fig. 4. *T. cucumerinum*, posterior region of an immature specimen showing smooth margin of the anterior testis and lobulation of the posterior testis.

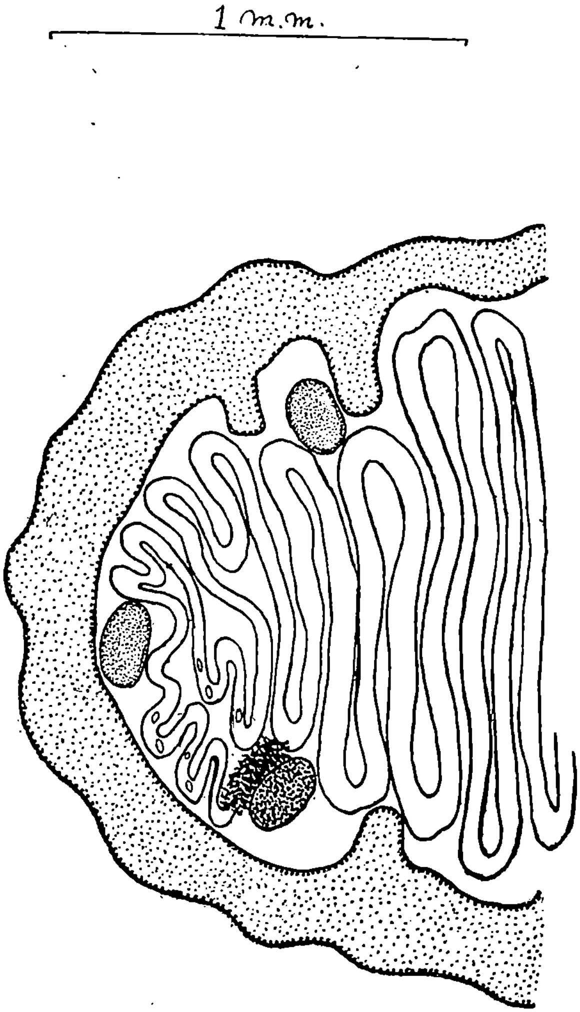

Fig. 5. *T. cucumerinum,* posterior region of an immature specimen showing smooth nature of both testes.

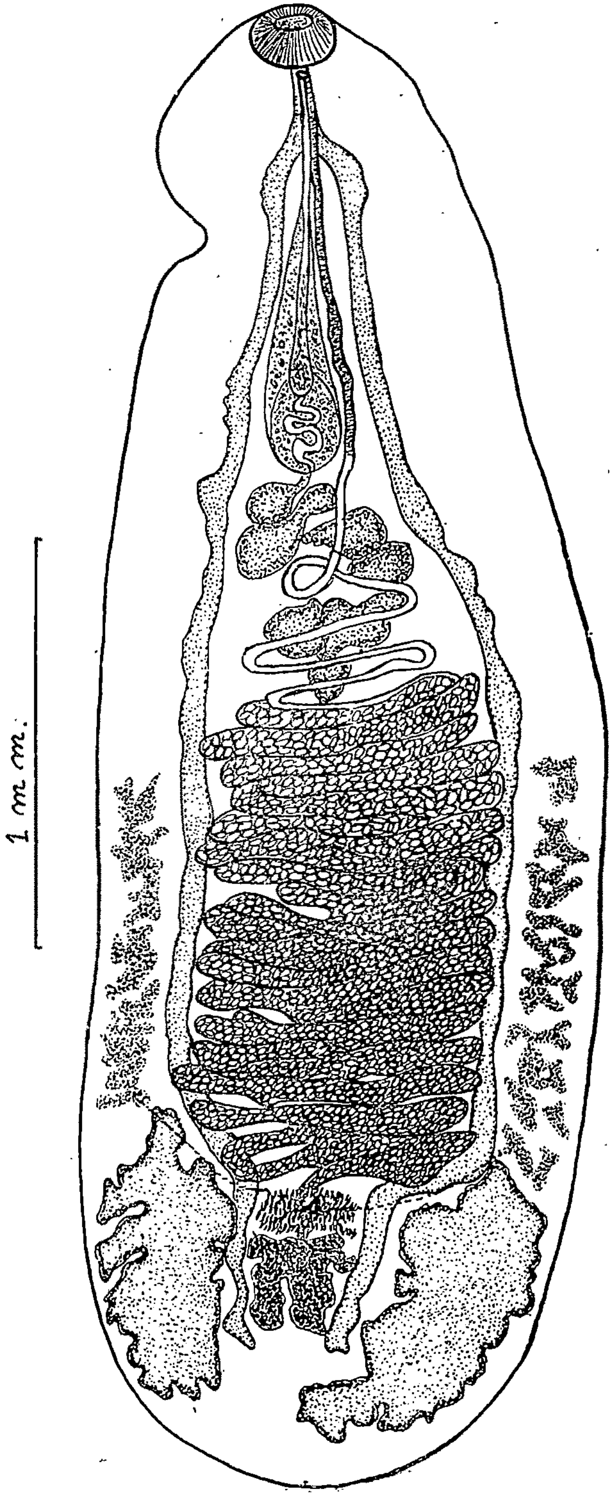

Fig. 6. *Catatropis indicus*, ventral view.

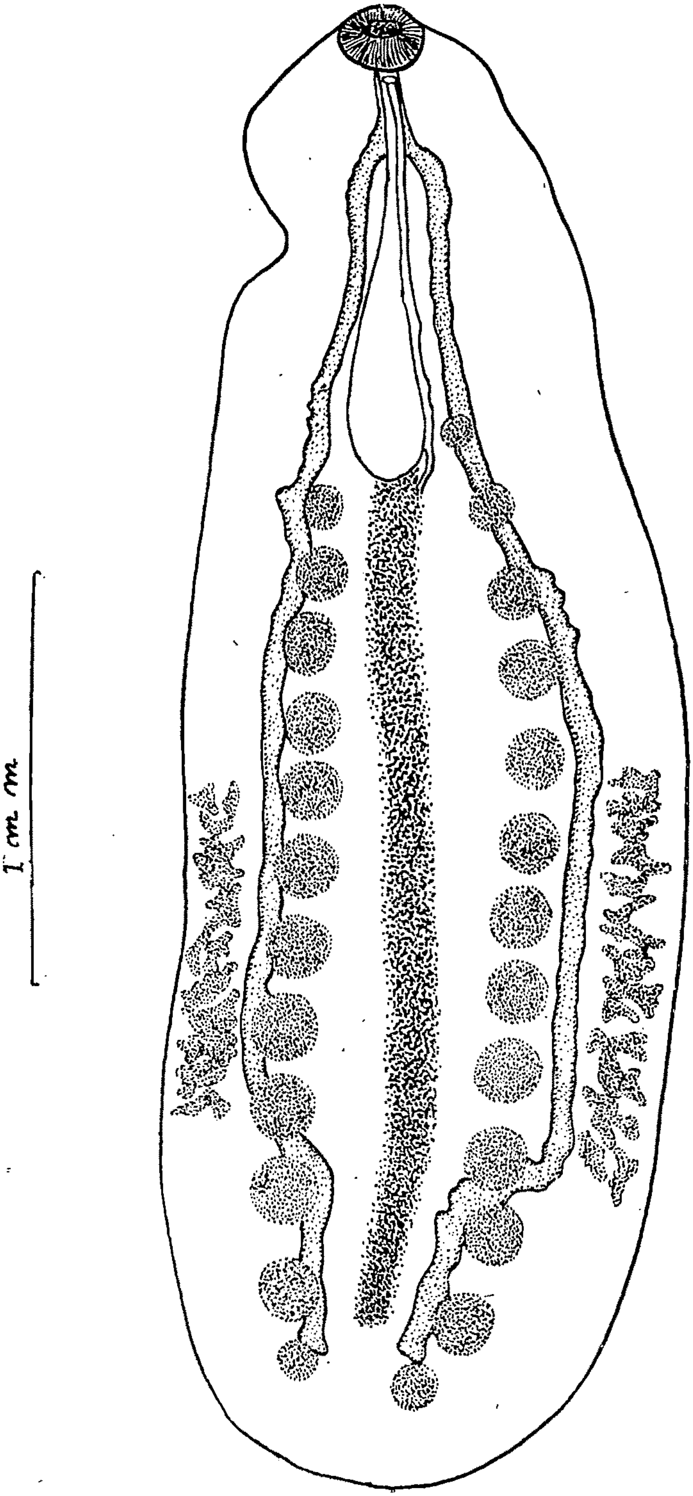

Fig. 7, *C. indicus*, showing the disposition of the ventral papillae and glandular ridge of the keel.

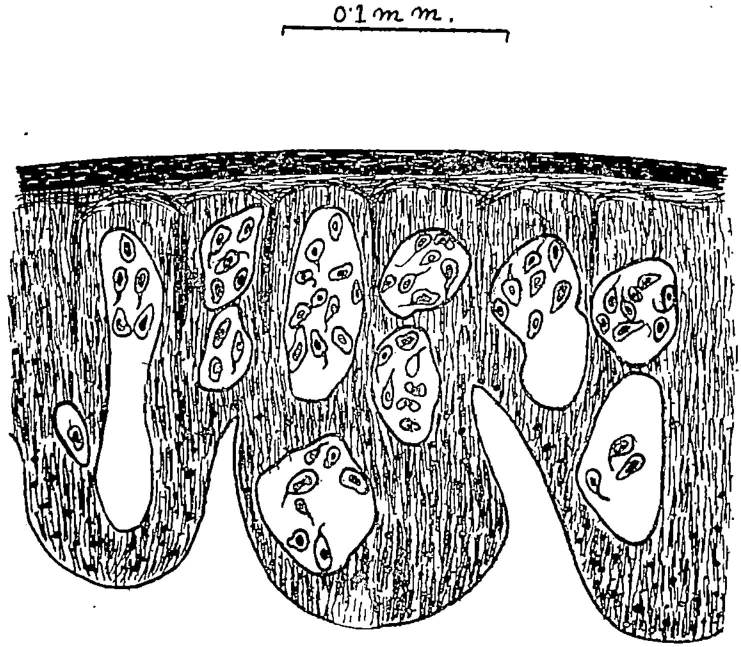

Fig. 8. Longitudinal section of *C. indicus* showing lateral papillae (non glandular).

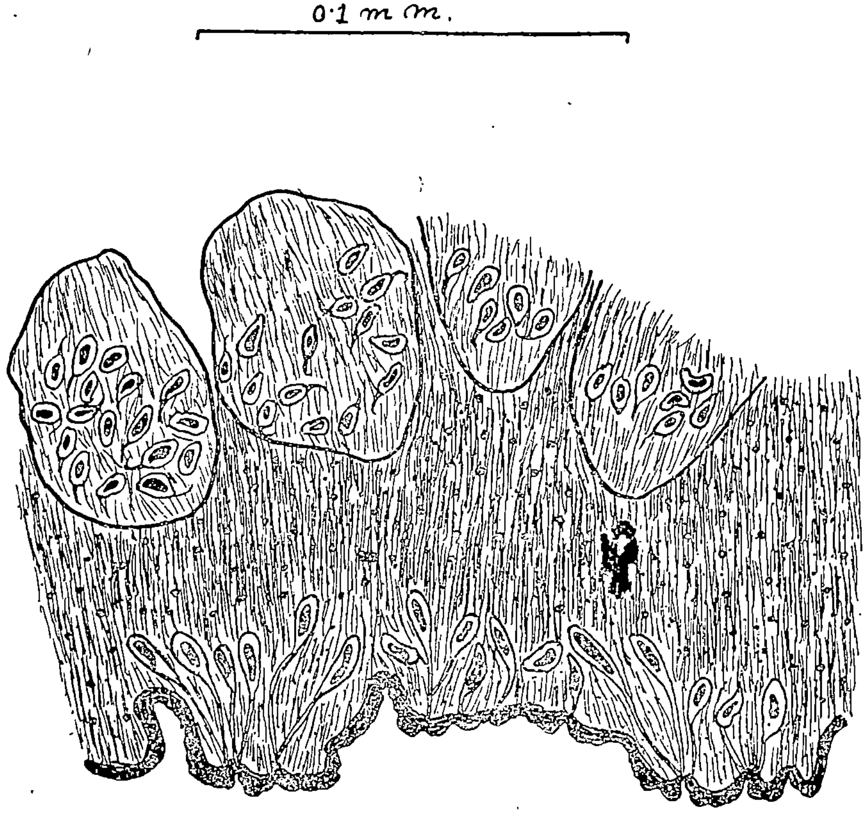

Fig. 9. Longitudinal section of *C. indicus* showing glandular character of its mid-ventral ridge/keel.

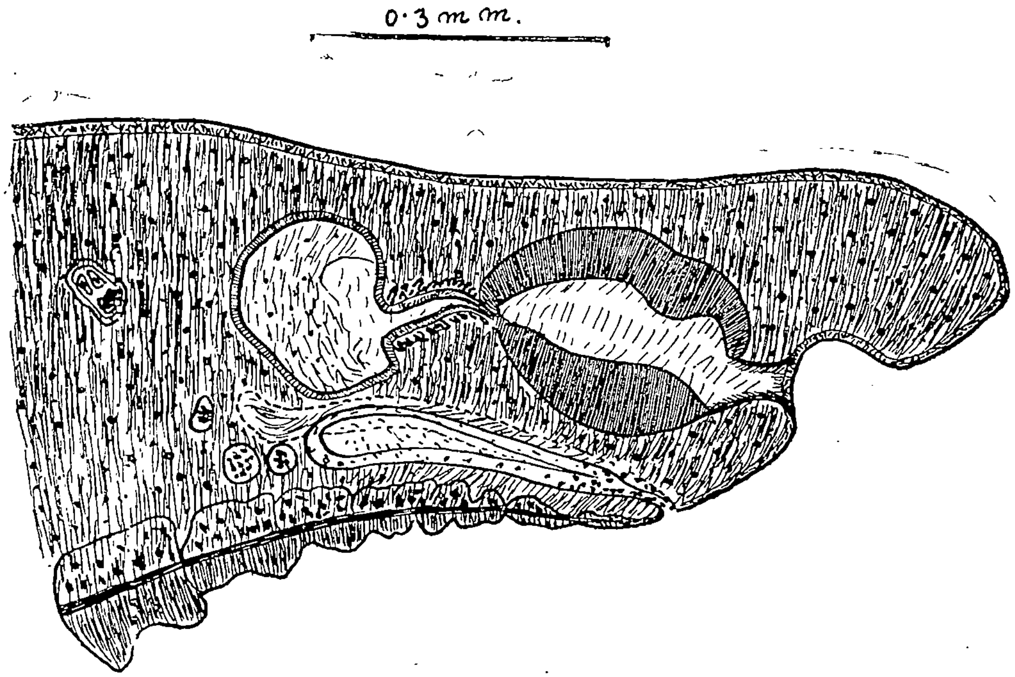

Fig. 10. *T. cucumerinum*, anterior region (reconstructed).

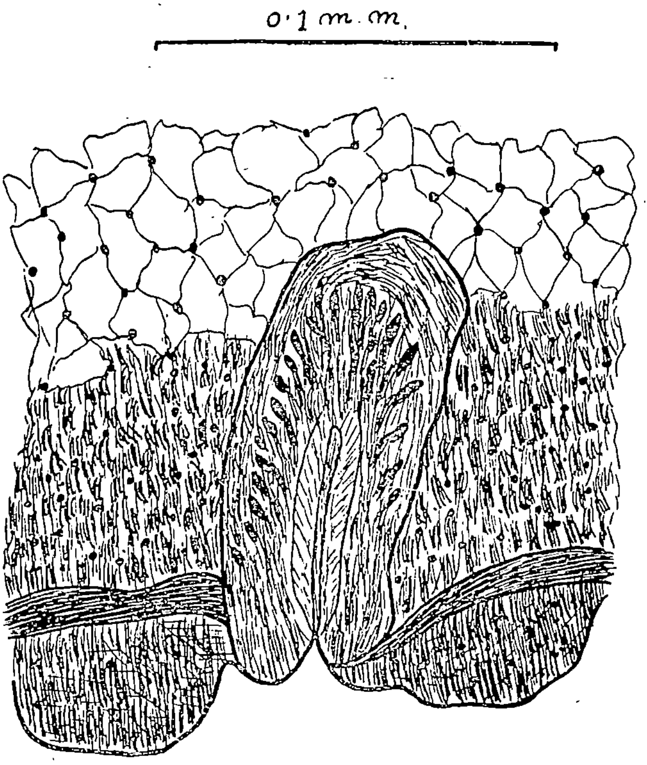

Fig. 11. Longitudinal section of *T. cucumerinum*, showing ventral papillae and glands.

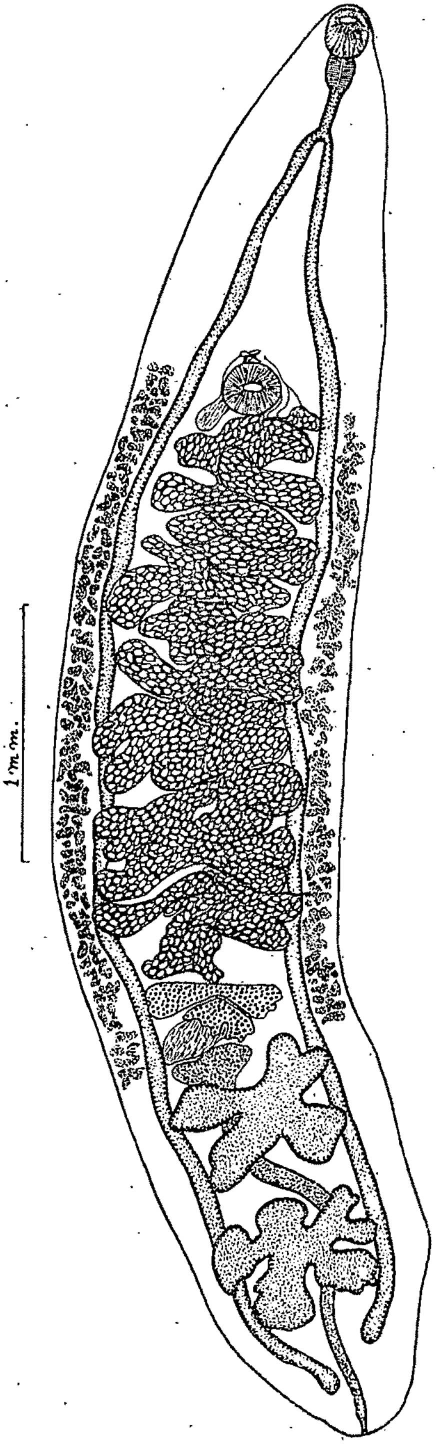

Fig. 12. *Opisthorchis obsequens*, ventral view.

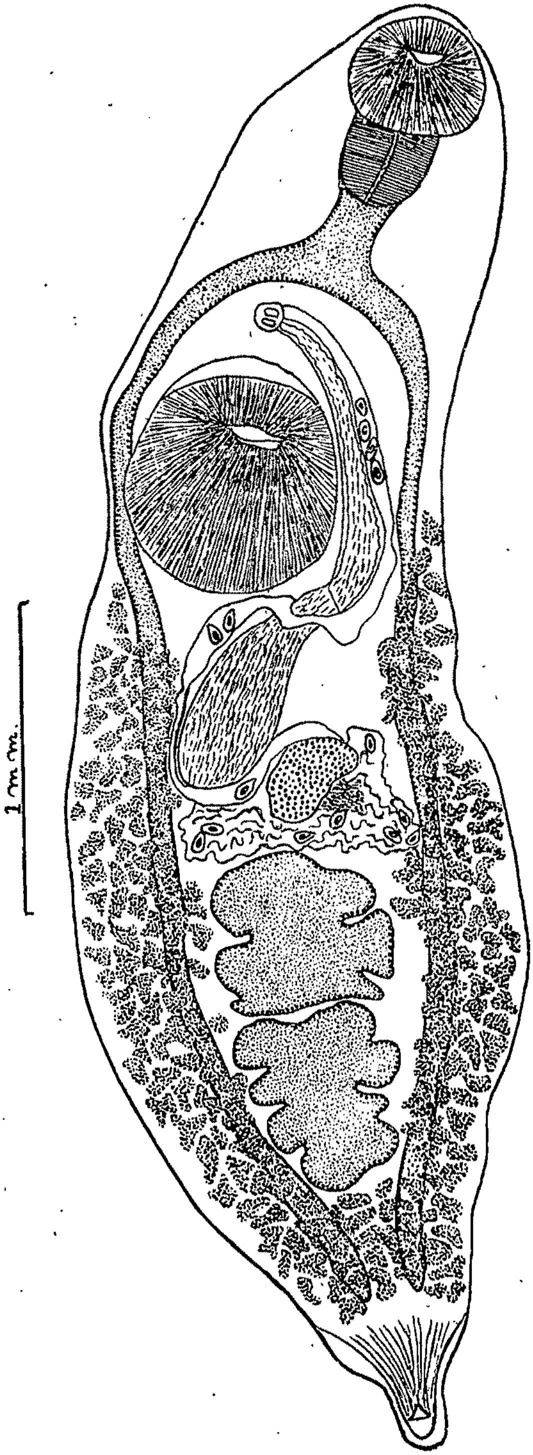

Fig. 13. *Psilochasmus obsequens*, ventral view.

STUDIES ON FUNGICIDES

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In recent years the antifungal properties of a large number of compounds have been investigated. It has been, however, found that such compounds have got only limited applications. Therefore, a search for compounds having a wider range of action was thought desirable.

Several new organo-mercury compounds have now been prepared and then fungicidal action studied. For comparison some already known compounds have also been included.

Mercuration of Phenols:

To the solution of phenols in alcohol or acetic acid, mercuric acetate dissolved in dilute acetic acid was added and the whole mass was heated on a water bath for 4 to 5 hours. The mercury compounds of phenols separated out. The following mercury compounds were thus prepared :—

(1) Tri-acetoxy-mercuric phenol, (2) Tri-chloro mercuric phenols (3) Di-acetoxy-mercuric-o-cresol (4) Tri-acetoxy mercuric-m-cresol, (5) Tetra-acetoxy-mercuric-m-cresol, (6) Di-acetoxy-mercuric-p-cresol, (7) Tetra-acetoxy-mercuric-o-chloro-phenol and (8) Di-acetoxy-mercuric-p-chloro-phenol.

Pyronine Dyes:

3-nitro-phthalic anhydride and 4-nitro-phthalic anhydride were condensed with phenol and resorcinol in the ratio of 1 : 2 mols in presence of anhydrous zinc chloride. In each condensation two isomeric products were formed which were separated as their acetyl derivatives with the help of acetic acid. One of the products dissolved in 30% acetic acid while the other dissolved in 80% acetic acid forming acetyl derivatives. These acetyl derivatives were hydrolysed by caustic soda solution into the corresponding phthaleins and fluoresceins. The following compounds were obtained :—

(1) 3-nitro-phenol-phthalein, (2) 4-nitro-phenol-phthalein, (3) 5-nitro-phenol-phthalein, (4) 6-nitro-phenol-phthalein, (5) 3-nitro-fluorescein, (6) 4-nitro-fluorescein, (7) 5-nitro-fluorescein and (8) 6-nitro-fluorescein.

The above phthaleins and fluoresceins were mercurated with mercuric acetate and the corresponding mercury compounds isolated. The mercury compounds were demercurated by bromine and potassiun bromide and the amount of bromine present in the bromo compounds was found by Carius method.

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* Abstract of the thesis submitted to Agra University for the degree of Doctor of Philosophy.

Azo dyes:

5-nitro-4-acetoxy mercuric-o-toludine was dissolved in dilute acetic acid and diazotised with calculated amount of sodium nitrite followed by the addition of excess of sodium acetate. This diazo compound was coupled with various sulphonic acids. The following mercurated azo dyes were obtained :

(1) p-hydroxy-azo-5′ nitro-p-hydrozy-mercuric-o-toluidine
(2) 5-nitro-4-hydrozy mercuric-2-methyl azo-a-naphthol
(3) 5-nitro-4-hydrozy-mercuric-2-methyl azo-B-naphthol
(4) 3-methyl-4-hydroxy azo.5′ nitro-p-hydroxy-mercuric-o-toluidine.
(5) 2-methyl-4-hydroxy-azo-5′ nitro-p-hydroxy-mercuric-o-toluidine.
(6) 3-methyl-6-hydroxy azo-5′ nitro-p-hydroxy-mercuric-o-toluidine.
(7) 2-4-dihyroxy azo-5′ nitro-p-hydroxy-mercuric-o-toluidine.
(8) 3-chloro-4-hydroxy azo-5′ nitro-p-hydroxy mercuric-o-toluidine.
(9) 2-hydroxy-5-chloro-azo-5′ nitro-p-hydroxy-mercuric-o-toluidine.
(10) 3-nitro-4-hydroxy-azo-5′ nitro-p-hydroxy mercuric-o-toluidine.
(11) 2-hydroxy-3-hydroxy mercuric-5 nitro-azo-5′ nitrop-hydroxy-mercuric-o-toluidine.
(12) 3-Nitro-4-Acetoxy Mercuric-2-Methyl Azo-B-naphthol-6′ sodium sulphonate.
(13) 5-nitro-4-acetoxy-mercuric-2-methyl-azo-a-naphthol-4-sodium sulphonate.

Azoic dyes:

Mercurated bases (Red K.B., Scarlet G. and Red T.R.) were dissolved in acetic acid. The solutions were diluted and cooled by adding ice to them. They were diozotised by adding slowly an ice cold solution of calculated amount of sodium nitrite followed by the addition of excess of sodium acetate. The diazo compounds thus formed were coupled with naphthols A.S., A.S.B.S., A.S.B.O. and A.S.G. (Red T.R. base is coupled with naphthol A.S.G. only). It was noted in the case of naphthol A.S.G., that two products were formed, one soluble and the other insoluble in acetic acid. They were separated using acetic acid.

The following mercurated azoic dyes were prepared :—

1. 5-chloro-4-acetoxy-mercuric-2-methyl-azo-2′ hydroxy-3′-naphthalilide.
2. 5-chloro-4-acetoxy-mercuric-2-methyl-azo-2′ -hydroxy-p-nitro-3′ -naphthanilide.
3. 5-chloro-4-acetoxy-mercuric-2-methyl-azo-2′-hydroxy -N-1-naphthyl-3′-naphthamide.
4. 5-chloro-4-acetoxy-mercuric-2-methyl-azo-(4-4′ bis-m-acete-aceto-toluidine).
5. 6-acetoxy-mercuric-4-chloro-2-methyl-azo(4-4′ bis-m-acete-aceto-toluidine).
6. 5-nitor-4-acetoxy-mercuric-2-methyl-azo-2′-hydroxy-3′naphthanilide.
7. 5-nitor-4-acetoxy-mercuric-2-methyl-azo-2′ -hydroxy-p-nitor-3′-naphthanilide.

8. 5-nitor-4-acetoxy-mercuric-2-methyl-azo-2′-hydroxy-N-1-naphthyl-3′-naphthamide.
9. 5-nitor-4-acetoxy-mercuric-2-methyl-azo-(4-4′-bis-m-acete-aceto-toluidine.

These mercurated azoic dyes were demercurated by bromine and potassium bromide. The bromine content of the demercurated products was estimated.

Fungicidal Testing :

The mercury compounds of the pyronine dyes were tested by converting them into sodium salt, as the sodiun salts of these compounds are soluble in water. In the case of compounds which are insoluble or sparingly soluble in dilute alkali (mercuro-derivatives of phenols and azo dyes) the fungicidal properties were tested using a fine suspension. A liquid media containing :—

1.	Sodium nitrate	.2%
2.	Dipotassium hydrogen phosphate	.1%
3.	Magnesium sulphate	.05%
4.	Ferric chloride	.05%
5.	Ferrous sulphate	.001%
6.	Sucrose	.3%

in distilled water, the pH of which has been adjusted to 7·4 was used. The tubes in which the activity was tested were arranged in rows of ten each and two rows were required for each compound. One row of tubes was used for Aspergillus Niger and the other for Penicillium Notatum.

4 m.gms. per c.c. of the solution of the sodium compound of the organo mercury derivatives were prepared. In the case of those mercury compounds whose sodiun salts could not be prepared a very fine suspension of the compound in distilled water (4-m-gms. per c.c.) was prepared. In each test tube 2 c.c. of the liquid media was added in the beginning. The mouths of the tubes were then plugged and the tubes sterilized in a steam autoclave sterilizer at 120° C for 30 minutes. The tubes were then allowed to cool to room temperature and then 2 c.c. of the prepared solution (or suspension) of the mercury compound was added in the first tube 2 c.c. were taken out and transferred into the second tube. It was shaken and then 2 c.c. from it were transferred into the third tube and so on till the ninth tube. Then 2 c.c. were taken from the 9th tube and thrown away, so that the 10th tube contained only 2c.c. of the liquid media and acted as control tube. The strength of the organo mercury compound went on decreasing by one-half from tube to tube. The tubes were then in-occulated with freshly prepared spore suspensions of aspergillus Niger and penicillium Notatum by taking 0·1 c.c. of it and putting in each of the test tubes separately. The tubes were then incubated at 37° C for 48 hours after which the results were determined by observing the growth of the fungii and comparing with the 10th tube.

Development of the Mercurated Azoic Dyes on Cotton Fabrics:

The development of the dye on fabrics took place in two stages. Firstly the fabric was impregnated in the naphthol solution and secondly this naphthol impregnated piece was dipped in the diazotised mercurated base.

Naphthol solutions were prepared by adding the required amount of hot 5% caustic soda solution to the paste of the naphthol in alcohol, thus getting a clear solution. By using this method 1%, 1·5% and 2% solutions of Naphthol A.S., A.S.B.S., and Naphthol A.S.B.O. were prepared, and .5%, .75% and 1% solutions of Naphthol A.S.G. (or A.T.) were prepared. Cotton pieces of 18″×9″ size were dipped in the above solution for 15 minutes, after which they were taken out one by one pressed uniformly to remove the extra liquid and then dried in diffused sun light.

The solutions of the mercurated bases were prepared by dissolving the base in the least amount of acetic acid and raising the volume of it with distilled water to the required strength of the base solution. Thus the strength of the base solutions was the same as that of the corresponding naphthol. For coupling with Naphthol A.S., Naphthol A.S.B.S. & Naphthol A.S.B.O., 1%, 1·5% and 2% solution of the mercurate Red K.B. base and mercurated scarlet G. base were prepared for each naphthol while for coupling with Naphthol A.S.G., ·5% ·75% and 1% solutions of mercurated Red K.B. base, mercurated scarlet G. base and mercurated Red T.R. base were prepared.

These solutions were cooled in an ice bath and then diazotised by an ice cold solution of calculated amount of sodium nitrite, followed by the addition of excess of sodium acetate. The naphthol impregnated fabrics were then immersed in the respective diazotised base for half an hour. The dyed pieces were then taken out, washed with excess of water and finally boiled with soap soda solution (1gm. soap, 1 gm. sodium carbonate and 100 c.c. water) for 10 minutes and then again washed with water and dried.

Testing of the Effectiveness of the mercurated Azoic Dyes on the Cotton Fabric Against the Attack of Micro-Organism:

Pieces of 11″×3½″ size were cut from the dyed fabric for tensile strength determination in the direction of the warp threads and then were put in a desicator containing methyl alcohol for sterilisation overnight. The media used was of the following composition :—

1.	Ammonium nitrate	3·0 gms.
2.	Potassium dihydrogen phosphate	0·25 gms.
3.	Magnesium sulphate	0·25 gm.
4.	Potassium chloride	·25 gm.
5.	Agar Agar	25 gm.
6.	Distilled water	1000 cc.

The pH of the media was adjusted to 6·4. 75 c.c. of the media was taken in each petri dish and then they were sterilised in an autoclave at 120° C for half an hour. The two ends of the test strips were rolled up so as to expose about 5″ of the central part and then put in the petri dishes containing the hot media. These petri dishes containing these strips were allowed to cool and then inocculated by pipetting 2-3 ml. of the Asoergilus niger spore suspension. These were then kept at a temperature of 30-2° C for 14 days at saturated humidity. Then the strips were washed free from agar agar with cold water, dried in air and their breaking strength (B.S.) was determined.

CONCLUSSION

From the results obtained, it would appear that the mercury derivatives of phenols can check the growth of the spores of Aspergillus Niger and Penicillium Notatum and are more effective than mercurochrome. It is also noted that the acetoxy mercuric phenols are stronger fungicides than chloro mercuric phenols. The mercurated phenols have shown greater tendency to check the growth of Penicillium Notatum than the growth of Aspergillius Niger.

The sodium salts of the mercury compounds of pyramine dyes have been tested in solution form for examining the antifungal property against the above mentioned fungii. All these compounds appear to be better fungicides than mercurochrome. It is noted that the presence of a nitro-group increases the antifungal activity of the compounds. The increase of the amount of mercury in the molecule, also increases the antifungal activity. It is also noted that the mercury compounds of nitro fluorescein are better fungicides than the mercury compounds on nitro phthaleins.

The mercurated azo dyes derived by coupling the mercurated Scarlet G. base with phenols have been noted better fungicides than mercurochrome. It is noted that these mercurated azo dyes check the growth of Aspergillus Niger more than that of Pencillium Notatum.

When the cotton pieces dyed with mercurated azoic dye were subjected to the rot and mildew testing it was noted that the pieces dyed with the unmercurated bases and in many cases with 1% mercurated base, were destroyed by the fungus spores while the pieces dyed with 2% and in many cases with 1·5% mercurated bases remained undamaged. From this it seems that such mercurated azoic dyes can be used effectively for rot and mildew proofing of textile materials.

STUDIES ON INDUCED MUTATION IN RED ROT ORGANISM OF SUGARCANE*

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Red rot caused by *Glomerella tucumanensis* (Speg.) Arx & Muller (*Colletotrichum falcatum* Went) is one of the most hazardous diseases of sugarcane and has often appeared in epiphytotic form, causing serious set-backs to sugar industry in India as well as in certain other sugarcane-growing countries. The periodic failure of certain resistant varieties of sugarcane and wide-spread epiphytotics of red rot have been attributed to the change in the parasitic vigour of the pathogen. Variability in *C. falcatum* thus appears to be a serious handicap in breeding for disease resistance and also in the development of other control measures of red rot disease on sound basis. Since, with the availability of ionizing radiation and radioactive isotopes, it has now been possible to study the mechanism of variability in plant pathogens, the intricate balance between the host and the parasite and other related aspects more thoroughly with the help of mutants than with the hitherto known methods, studies on induced mutation in red rot organism (*C. falcatum* isolate No. 244) were initiated using radiation as mutagens and the results obtained are reported here.

Different sources of ionizing radiation, *e. g.*, beta radiation from P^{32}; gamma radiation from cobalt^{60} and Radon gas; X-ray from 220 KV-therapeutic machine and fast neutrons produced through cascade generator and non-ionizing radiation like ultraviolet light, were employed in the present study. For qualitative induction of mutation, growth phase method, which 'magnifies' the expression of induced mutation, was found to be satisfactory so far as this organism is concerned. Usual method of spore-irradiation was employed for the study of frequency of morphological mutation with ultraviolet light at 2537 A° wave length and it was found that mutation rate increases with the increase in dose and decrease in survival rate of conidia but at extremely low survival rate it tends to decline which appears to be the characteristic mutagenic effect of ultraviolet light.

Among other morphological mutants, one which resembles the dark type and has elliptic conidia instead of the normal falcate ones and the other which shows loss of pigment in the spores appear to be important taxonomically and physiologically, respectively. These morphological changes did not affect the parasitic vigour of the organism as is indicated from the pathogenicity tests. The mutants retained their characters even after passage through the host and also did not show any tendency of reversion or change in any other direction indicating that the mutant characters are induced due to change in genetic material. The mutant with loss of pigment in conidia showed poor spore germination as compared to that of the wild type (pigmented spores) and it appeared that loss of pigment probably has deranged certain metabolic processes leading to spore germination. The pigmented spores of *C. falcatum* (wild type) were found to be more sensitive to the deleterious effect of ultraviolet light at 2537 A° wave length when used as a source of irradiation with Wood's glass filter whereas in the case of mutant (non-pigmented spores) the germination was unaffected. The mutant spores without pigment appear to be useful material for further investigation of radiation effect particularly in respect of pigment protection.

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Biochemical mutants of *C. falcatum* induced by means of irradiation with radioactive isotope of phosphorus (P^{32}) in growth phase showed deficiency for certain vitamins, *e.g.*, p-aminobenzoic acid (PABA), biotin, thiamine, biotin and choline, thiamine and choline and certain amino acids. No correlation, however, appeared to exist between the nature of deficiency and the morphological characters as mutant deficient in biotin or thiamine were either dark type with sparse sporulations or typical light type having abundant sporulations.

The biochemical mutant deficient in PABA showed absolute deficiency for the vitamin and was sensitive even at as low a concentration of PABA as 2×10^{-4} μg./ml. The optimum concentration of PABA required for growth was found to be 5×10^{-2} μg./ml. Higher concentrations of PABA, even upto 300 μg./ml. did not, however, show any inhibitory effect. The mutant showed linear response in growth with the concentration of PABA ranging from 2×10^{-4} to 4×10^{-3} μg./ml. and, therefore, was found to be suitable test organism for microbiological assay of PABA. The mutant was maintained on artificial culture medium for a number of asexual generations ranging over a period of several years without any indication of reversion. It also maintained its characteristics even during passage through the host, showing thereby that the mutant is quite stable. A suitable medium for the purpose of microbiological assay was developed. Indications of suitability of a mutant of *C. falcatum*, deficient in biotin, as test organism for bioassay of this vitamin were also obtained.

The wild type strain (cf.244) used in these studies was found to synthesise PABA in the cultural broth as was evident from the fact that the culture filtrate of 9-day old culture of the wild type supported normal growth of the PABA-deficient mutant. It is also indicated that biosynthesis of PABA is maximum during the active growth phase of the organism. The synthesis of PABA by the wild type was qualitatively confirmed by paper chromatography (descending) and by utilising the principle of competitive inhibition using sulfanilamide which is an antimetabolite of PABA. Since addition of sulfanilamide in the medium completely inhibited the growth of both the mutant and the wild type, it appeared that PABA, whether incorporated or synthesised, was completely dislodged from its function. This indicated th t the synthesised PABA was analogous in structure to sulfanilamide. The quantitative estimations of PABA were made by UV absorption spectrophotometer and the results obtained confirmed the earlier indications that the production of PABA was greater during the active growth phase of the organism. Isopropyl alcohol was found to be a suitable solvent for such studies.

The pathogenicity tests of different biochemical mutants of *C. falcatum* yielded interesting results. The mutants deficient in PABA, biotin, biotin and choline, and thiamine were non-pathogenic on sugarcane variety, Co. 647; those deficient in thiamine and certain other unidentified growth factors including amino acids were partially pathogenic while mutants deficient in biotin, thiamine, and thiamine and choline were as pathogenic as the wild type. These results show that loss of ability of an organism to synthesise particular metabolite does not always result in loss of pathogenicity. It was also observed that the mutants having similar deficiencies do not always show the same trend in pathogenicity. Since biochemical mutant, deficient in PABA was found to be completely avirulent on sugarcane variety, Co. 647 and showed very restricted growth on sugarcane juice of this variety, it indicated that loss of virulence in this case was due to the non-availability of growth factor in the host or in other words the host provided inadequate nutrition. This was further confirmed by incorporating PABA in the host system through roots which resulted in partial restoration of pathogenicity both on sugarcane stalk and leaves. As re-isolations from the artificially infected canes yielded cultures which still required PABA for their growth it was evident that increase in its virulence on sugarcane as a result of supplementation of PABA was not due to reversion to prototrophy but due to the availability of the growth factor in the host. This supports Garber's hypothesis that adequate or inadequate nutrition available in the host would determine whether the pathogen will be virulent or avirulent, subject to the inhibitory environment being ineffective (Garber, 1956). Since the wild type produces good infection on sugarcane variety, Co. 647 it shows that inhibitory environment does not play any role in the loss of pathogenicity of the *C. falcatum* mutant.

It has also been observed that certain mutants of *C. falcatum*, deficient in biotin or thiamine, were either avirulent or were as virulent as the wild type. This may be due to the difference in their ability to utilize certain concentrations of these vitamins as biotin and thimaine are reported to be available in sugarcane juice, though in low concentrations.

Isolations made from naturally red rot affected canes of different varieties collected from different parts of the country showed lot of variability in morphological characters as also in their growth response on the minimal medium. Deficiency analysis of 21 isolates revealed that seven strains were completely deficient in biotin, three showed partial deficiency for biotin, whereas the remaining were prototrophic. None of the morphological characters was associated with biotin deficiency. Pathogenicity test of one of the biotin-deficient strains on sugarcane variety, Co. 647 showed that it was as virulent as the wild type. It was thus concluded that as biotin is available in sugarcane juice, the host serves a suitable medium for selection, preservation and multiplication of biotin-deficient strains that might arise in nature as a result of spontaneous mutation. Mutation in nature may arise in any direction including the requirement for different growth factors but their selection and preservation depend upon the availability of suitable growth conditions in the host.

Experiment conducted to study the synergistic effect of mixed cultures, depicting deficiencies for PABA, thiamine and biotin, revealed that none of the large number of combinations of several biochemical mutants showed any growth on the minimal medium unless either one of the two components initiated slight growth on its own or the growth factor essential for one of the two components was made available in the medium. The mutant deficient in PABA could be made to grow, for two consecutive generations, on the minimal medium devoid of PABA but in association with the biotin-deficient mutant by creating favourable growth conditions for the latter which confirmed that synergism between the two deficient cultures occurred provided one was able to grow.

It has been observed that mass sub-culture from the mixed population of two deficient mutants produced prototrophic culture, *i.e.*, capable of growing on the minimal medium. Isolations of single spore colonies from the prototrophic culture yielded auxotrophic strains indicating the formation of a heterokaryon as a result of mixed growth and dissociation of two nuclei during the formation of spores (conidia being uninucleate).

In an attempt to study the functioning of parasexual cycle in this organism, large number of single-spore colonies were isolated from the mixed population of two deficient mutants, and this yielded four single spore cultures capable of growing on the minimal medium. This has been attributed to the formation of a heterozygous diploid nucleus as a result of fusion of two genotypically different haploid nuclei, one showing deficiency for PABA and the other for biotin. Further single-spore isolations yielded both haploid (auxotrophic) and diploid (prototrophic) progenies showing the unstability of diploid nucleus; being the abnormal introduction.

Experiment conducted to study the effect of mixed cultures on pathogenicity showed that mixture of virulent, prototrophic and avirulent, deficient strains produced greater infection than the individual components on majority of the varieties of sugarcane tested which can be explained on the basis of synergism, demonstrated *in vitro* in the experiments reported above. Likewise, mixture of two avirulent strains also produced greater infection than the individual components but when mixed inoculum of two virulent isolates was used, the infection was, on the contrary, generally lower than that produced by the individual components. Chances of such phenomena occurring in nature in red rot disease are abundant as spores from different strains, appearing due to spontaneous mutation, may easily get mixed up, particularly during monsoon season when water freely flows from one field to another. These mechanisms, therefore, may explain the evolution of new and more virulent strains in nature which cause breakdown of important commercial sugarcane varieties resistant to red rot disease.

It has been concluded that induced mutants, particularly those showing alteration in pathogenicity and deficiency for certain growth factors, are very useful research tools for the study of host-pathogen relationship and for studying the possible underlying causes of variability that is responsible for creating epiphytotic conditions in red rot disease.

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MORPHOLOGY OF A HOVER FLY *SYRPHUS BALTEATUS* DE GEER* (SYRPHIDAE : CYCLORRHAPHA : DIPTERA)†

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In view of the fact that no comprehensive morphological account has been published so far on any typical Indian Diptera, the present work was undertaken primarily to fill up that lacuna in addition to enriching the existing literature on the morphology and anatomy of Diptera with special reference to the family Syrphidae. During the course of these investigations a special attention has been paid to work out the structural details of the various systems and an effort has been made wherever possible to correlate these with their functional aspects. The hover fly *Syrphus balteatus* De Geer was selected on account of its availability in abundance during the spring months in Agra, and appropriate size of its body. Another factor that weighed in favour of its selection, is its great economic importance as a cross-pollinator of numerous garden and wild plants.

The text of the thesis is divided into eleven chapters. Besides the main volume I containing the typed manuscript of the thesis, a second volume comprising the published work by the author, on the morphology of some Diptera, is submitted. The observations on the morphology of *Syrphus balteatus* De Geer may be summarised as follows :—

Organs of support and locomotion—The head of *Syrphus balteatus* is hypognathous. The compound eyes are holoptic in the male and dichoptic in the female. The post occipital, the temporal, the sub-ocular and the antennal sulci are the only lines of demarcations left on the cranium. The faintly marked coronal sulcus is also represented. The anterior surface of the head capsule, bounded laterally by the compound eyes and ventrally by the oral fossa represents the frons or the face of the fly. The sclerotised clypeus is removed away from the head on to the anterior membranous surface of the basal part of the proboscis. In the absence of any complete sulcus, the whole posterior surface of the head is considered as the occipito+postgenal+hypostomal complex, in the centre of which lies the greatly reduced foramen magnum. The body of the tentorium forms the ventral border of the foramen magnum and the former is fused with the head wall for some distance. The component parts of the tentorium are the anterior tentorial, dorsal tentorial and the posterior tentorial arms. The three segmented antenna is aristate. The arista is formed of three annuli. The proboscis is formed by the clypeus, the labrum-epipharynx and the labium. This is divided into three regions—the proximal basiproboscis, middle mediproboscis and terminal distiproboscis.

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The three thoracic segments form a composite structure, where the prothorax has been greatly reduced, the mesothorax extremely well developed, while the metathorax is almost vestigial. The propleuron is divided into an anterior proepisternum and posterior proepimeron by a pleural sulcus_1. The prosternum is distinguished into the presternum, the probasisternum and the profurcasternum. Mesonotum is composed of alinotum and postnotum. The alinotum is divided into the prescutum, the scutum and the scutellum. The postnotum, a rectangular, vertical, sclerotised plate lies beneath the scutellum and bears internally the extremely well developed posterior mesothoracic phragma. The anterior mesothoracic phragma is a thin vertical plate indicated externally as the antecostal sulcus in front of the prescutum. The mesopleuron is complicated and is divided into an anterior mesepisternum and posterior mesepimeron by the pleural sulcus_2. Each of these portions is further sub-divided into a dorsal and a ventral area. The mesosternum is very likely composed of portions of sternum, precoxal bridge and parts of episterna. The metasternum is represented by a vestigial transverse plate. The metapleuron though extremely reduced presents all the essentials of a typical pleuron. The metafurcasternum is a small sclerite in between the metacoxal cavities and the area in front of it represents a part of the basisternum and precoxalia of the metathorax.

The appendages of the thorax are: the three pairs of legs, the mesothoracic functional wings and the halteres for balancing in flight. Each leg comprises a coxa, the trochanter, the femur, the tibia and the five segmented tarsus. The fifth tarsomere or the pretarsus bears a pair of claws, a pair of pulvilli, a bristle-like empodium and the unguitractor.

The costa anterior (CA), the costa posterior (CP) the radius anterior (RA), the media (M), the cubitus (CU) and the anal (A) are the longitudinal veins in the wing, the humeral (H), the proximal radio-medial (PRM) and the distal radio-medial (DRM) are the cross-veins. The whole wing surface is divided into six open and six closed cells. The wing is supported at the base by three axillaries. The haltere is distinctly divided into three regions, the basal scabellum, a narrow elongated pedicel and a distal swollen capitellum.

The abdomen is constituted by ten segments in both male and female. The first five abdominal segments are similar in the two sexes. Segments 6-10 lie curved ventro-anteriorly in the male and form a 'substitutional ovipositor' in the female. Six pairs of abdominal spiracles lie in the pleural membranes from the second to the seventh abdominal segments.

Thirteen muscles are associated with the proboscis, four of which are extrinsic. Each antenna, has two intrinsic and two extrinsic muscles. Prothoracic muscles include the dorsals, the lateral and the ventrals. The indirect wing muscles include six pairs of dorsal longitudinal bundles, two lateral oblique dorsal muscles, two tergosternal muscles and two tergal remotors of the coxa; direct wing muscles are those of the axillaries and the epipleurites. Muscles of the coxa and the intrinsic leg muscles are discussed separately. Metathoracic musculature is greatly reduced. Abdominal muscles comprise the dorso-longitudinal, the ventral longitudinal and the lateral muscles. Spiracular and genital muscles are separately mentioned.

Digestive system—In a fly measuring about 8·4 mm in length, the alimentary canal is about 17·75 mm. The mid-gut is the longest region of the alimentary canal. The fore-gut is the shortest and narrowest part comprising the pharynx, the oesophagus and the crop. The mid-intestine is divided into anterior and posterior limbs. The former is the straight tube and the latter lies coiled up. The 'nidi' are absent and the regenerative cells are singly scattered. Both mero- and holocrine secretions are recognised. The true peritrophic membrane is absent, the thick striated epithelial border itself seems to provide the protective covering to the epithelium. The pyloric valve is poorly developed. The hind gut is demarcated into an anterior coiled part, the rectal sac and the hinder highly muscular tubular rectum. The rectal sac bears four prominent rectal papillae, which are marked externally as oval discs.

Circulatory system and associated tissues—The diaphragm and four pairs of alary muscles support the heart. The heart is five chambered and distinct five pairs of ostia are recognised. The long thin walled aorta extends from the posterior part of the first abdominal segment to the bases of the antennae. The aorta forms a small aortic funnel dorsal to the oesophagus and terminates at the base of the antennae forming an antennal pulsating organ.

Excretory system—Two pairs of long, slender, malpighian tubules are present. On either side members of a pair unite to form a common tube before opening into the alimentary canal at the junction of the mid-gut with the hind-gut. Histologically, the malpighian tubule shows no distinct peritoneal coat and even the single layer of striated fibres below it, is also lacking. A single layer of striated epithelial cells is supported on a basement membrane.

Organs of respiration—Eight pairs of spiracles both in the male and the female help in the communication of the tracheal system with the exterior. Two of these pairs represent the thoracic spiracles and the remaining six abdominal, being present on the second to the seventh abdominal segments. Spiracles are divided into three types on the basis of closing mechanism; (i) the anterior thoracic spiracles of a rather simple type; (ii) the posterior thoracic spiracles of a complex nature and (iii) the abdominal spiracles with a lever mechanism.

The dorsal segmental trachea opens into a rather wide tube, the dorsal longitudinal trunk in each segment. Six dorsal tracheal branches supply the dorsal longitudinal half of the abdomen up to the fifth segment. In both male and female the sixth and the seventh abdominal segments are supplied by dorsal tracheae of the respective segments. The remaining terminal segments are supplied by the branches from the lateral longitudinal trunk. The two dorsal longitudinal trunks are joined to one another in the abdomen by five and six dorsal commissures in the male and the female, respectively.

The ventral longitudinal half of the abdomen is supplied by seven ventral tracheae in the female, while in the male are present, in addition, two accessory ventral tracheae. No ventral commissure is formed in the abdomen. The tracheae supplying the viscera arise both from the lateral and the dorsal longitudinal trunks. Both the lateral and the dorsal longitudinal trunks form series of inter connecting air-sacs in the thorax.

A pair of cervical tracheae—the anterior continuations of the parenteric sacs (formed by the dorsal longitudinal trunks) enter the head and form extensive air-sacs occupying the space between the walls of the head capsule and the internal structures.

Nervous system—The central nervous system is constituted by the cephalic nervous mass, the thoracico-abdominal complex and the abdominal ganglia. The supra-oesophageal ganglion or the brain proper lacks any external manifestation of its proto-, deuto- and tritocerebral parts. The antero-dorsal part of the brain gives rise laterally to well developed optic lobes. The thoracico-abdominal ganglionic complex is the fusion product of the three thoracic ganglia and the first abdominal ganglion. Two visible abdominal ganglia in the abdomen represent the third abdominal nerve centre and the fourth composite abdominal ganglion, respectively.

A detailed histological structure of the proto-, deuto- and the tritocerebral regions of the brain, the sub-oesophageal ganglion and the optic lobe is described. Thoracico-abdominal ganglionic complex supplies nerves to the muscles of the thorax, the legs, the wings, the halteres and the first reduced abdominal segment. The fourth composite abdominal ganglion supplies nerves to the 4-10 abdominal segments.

Reproductive system—Sexes are separate with distinct sexual dimorphism. The reproductive system comprises a pair of testes, a pair of testicular ducts or vasa deferentia, a pair of accessory glands, an unpaired ejaculatory duct and the external genitalia. Each testis corresponds to a single sperm tube, which is filled with the maturing male germ cells at different stages of their development. The vasa deferentia are enclosed in a common sheath. The ductus ejaculatorius forms a prominent ejaculatory sac in the ninth abdominal segment. Tubular, off-white accessory glands pour their secretions by separate ducts into the anterior part of the ejaculatory duct. The complex male genitalia is constituted mainly by the structural modifications of the ninth abdominal segment. The phallic and periphallic organs are elaborately discussed.

The reproductive organs of the female include a pair of ovaries, a pair of small lateral oviducts, a single median common oviduct posteriorly opening into the genital chamber, a pair of accessory glands, three spermathecae and the external genitalia. 35-45 polytrophic egg tubes or the ovarioles constitute a single ovary. The median oviduct is demarcated posteriorly from the genital chamber by the opening of the spermathecal ducts at the junction of the former with the latter. Two spermathecal ducts unite to form a common spermathecal duct and the third has its own independent duct. Accessory glands are narrow, tubular structures, opening into the genital chamber at its latero-anterior walls. The sixth to the tenth abdominal segments constitutes a 'substitutional ovipositor'.

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ON *SPIROCERCA LUPI* (RUD; 1809) CHITWOOD, 1933 IN *EQUUS ASINUS*[*]

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In the course of an investigation into the aortic lesions in *Equus asinus* developing stages of this nematode, earlier reported by Pande *et al* (1961), were collected from the characteristic nodules encountered in ten of the twenty-eight donkeys, available for examination while the thirteen ponies, available for study after autopsy, were free from this infection.

The youngest form (Figs. 1 & 2), collected in the process of invading the intimal lining, measured 4·67 mm. in length and 0·17 mm. in maximum width; with the buccal capsule 0·038 mm. deep, the nerve ring at 0·14 mm. distance from the anterior end; anterior region of the oesophagus measuring 0·24 mm. and its posterior part of 1·27 mm. in length; and the tail 0·07 mm. long with its tip provided with six papillae. This stage approximated, in its form, the third stage larva recovered by Gupta (1961) from the liver of a dog. The other stages were the fourth and fifth stage juveniles. One of the specimens to develop into a female measured 25·04 mm. in length and 0·57 mm. in maximum width; with the buccal capsule 0·07 mm. deep; nerve ring at 0·36 mm. distance from the anterior end, anterior part of the oesophagus measuring 0·53 mm. with the posterior part 3·02 mm. long; vulva (situated anterior to the junction of the oesophagus and intestine) at 3·34 mm. distance from the anterior end; and tail 0·17 mm. long. A similarly developed male measured 18·92 mm. in length and 1.51 mm. in its maximum width; with buccal capsule 0·07 mm. deep; nerve ring situated at a distance of 0·31 mm. from the anterior end; anterior part of the oesophagus 0·38 mm. long and its posterior part 2·81 mm. long, tail 0·15 mm. long; and well-developed spicules 2·39 mm. and 0·56 mm. in length. The nodules, present mostly on the intimal coat, varried in size from pea-seed to nearly one inch in diameter of which one had a prominently pitted surface and was protruded towards the adventitial coat. The lesions, of nearly light grey in colour, were in some cases dark brownish to blackish and the contained worms appeared as irregular streaks. In some nodules, small openings through which the posterior regions of the worm were visible (Fig. 3) showed the anterior part lying deep into the aortic tissue. In addition to the nodulated character, the lesions also exhibited tracts left by wandering parasites.

Four series of stained sections of the characteristic nodules were studied to assess the nature and extent of the damage caused by these stages. Pathological changes, involving all the three layers, were most marked in the medial and adventitial coats. The worm, usually located in the tunica media, had caused a comparatively greater damage in the outer most coat. The changes, in the intimal coat and particularly in the vicinity of the parasite, revealed a marked thickening and a desquamation of the endothelial lining. An infiltration with cellular elements particularly numerous eosinophils and some lymphocytes with a few red blood cells was noticed. The previous tunnels, connected with the nodular cavity, were calcified (Fig. 4). In the medial coat, spaces around the parasite contained extravasated blood. The cellular elements, mostly eosinophils and lymphocytes, with masses of necrotic debris, were visible. Majority of the red-blood-cells had taken a brownish pigmentation. Necrosis, in initial stages was apparent on the periphery of such cavities. Besides, in the neighbourhood of such spots a generalised infiltration with reactionary cells particularly eosinophils, lymphocytes and few of macrophages was evident. A few fibroblasts had also appeared. Extensive haemorrhage particularly in between the hundles of elastic fibres was revealed, the affected fibres appearing widely separated (Fig. 5). A yellow pigmentation, inside the cells and their intercellular spaces and invariably seen in the vicinity of the worm, was less marked than that seen in case of onchocercal lesions reported elsewhere. Calcified feature of some of these tunnels, in this coat, was also observed. Occurring near the junction of the medial and adventitial coats, numerous eosinophils had formed a continuous belt (Fig. 6). In consequence of a heavy infiltration, from reactionary cells particularly with eosinophils and lymphocytes, the tunica adventitia had apparently lost its normal structure. The blood vessels were moderately thickened and congested (Fig. 7).

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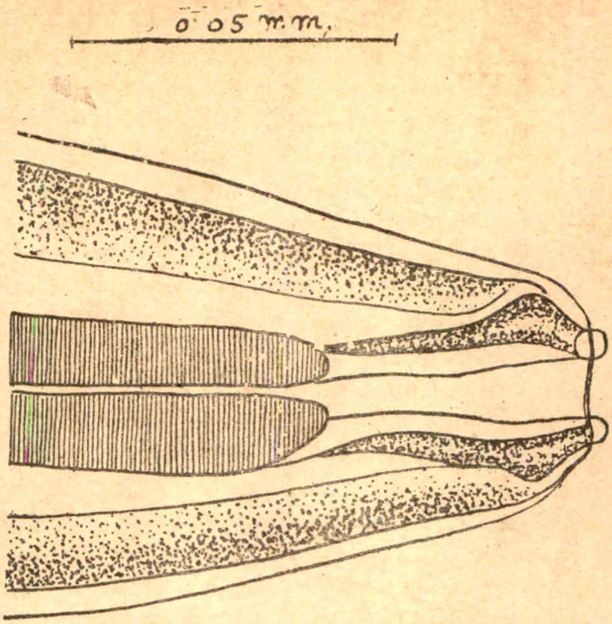

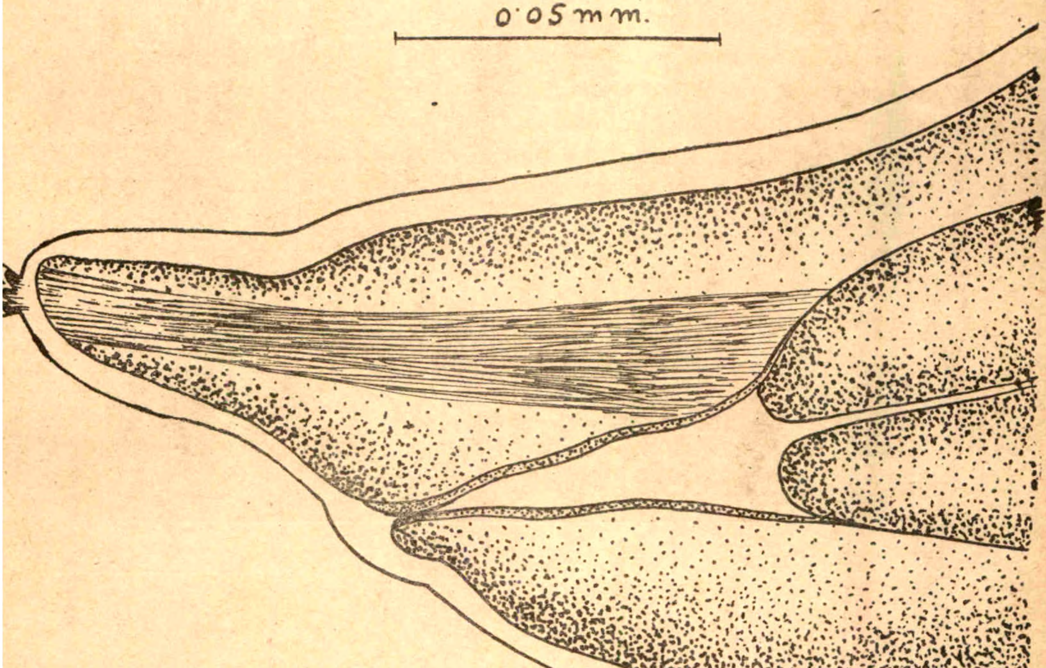

Figs. 1 & 2 (Camera lucida drawing).

Fig. 1. Anterior end of the youngest juvenile.

Fig. 2. Posterior end of the same with six papillae at the tip of tail.

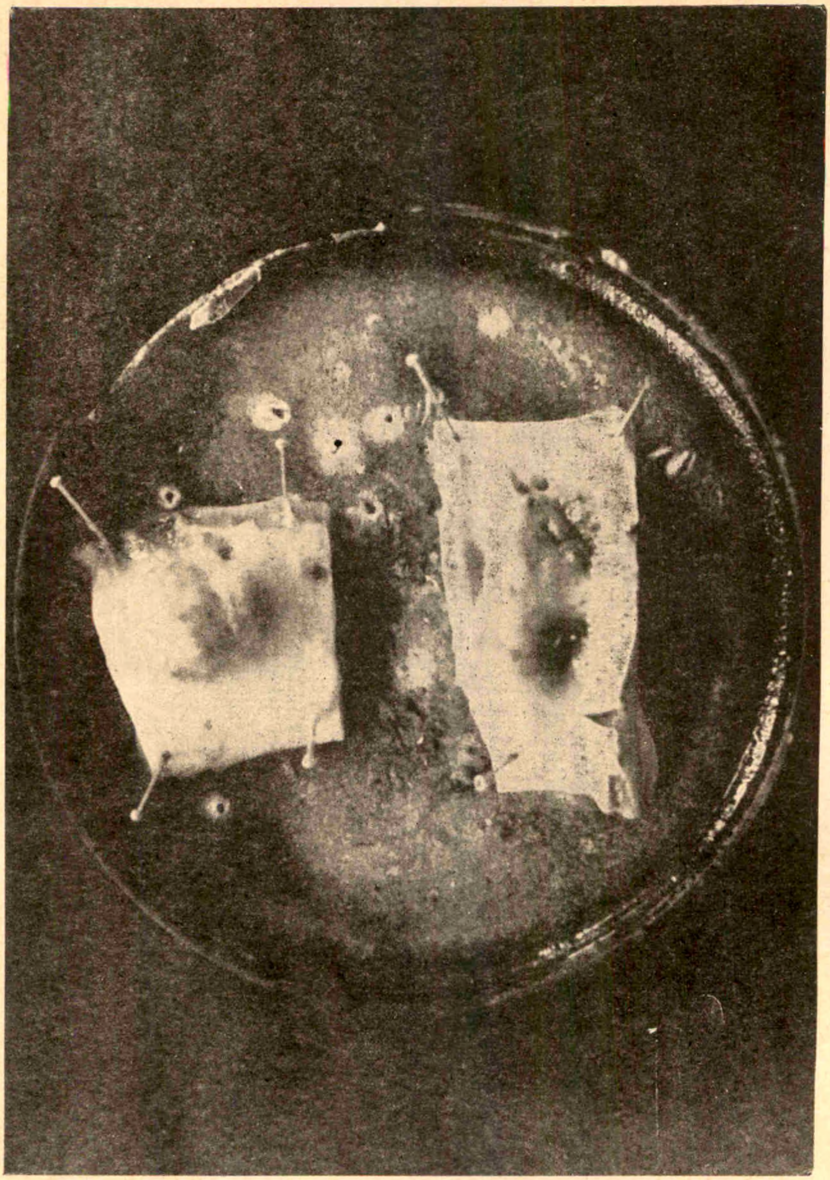

Fig. 3. Photograph of a portion of internal lining of aorta showing the characteristic nodules.

Figs. 4 to 7 (Photomicrographs).

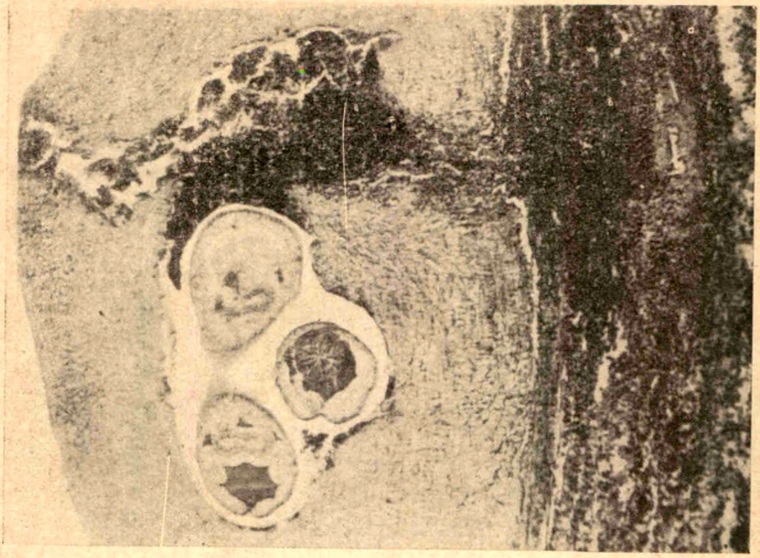

Fig. 4. A section of aorta showing calcified tunnel, previously occupied by worm, in intimal coat. x 70.

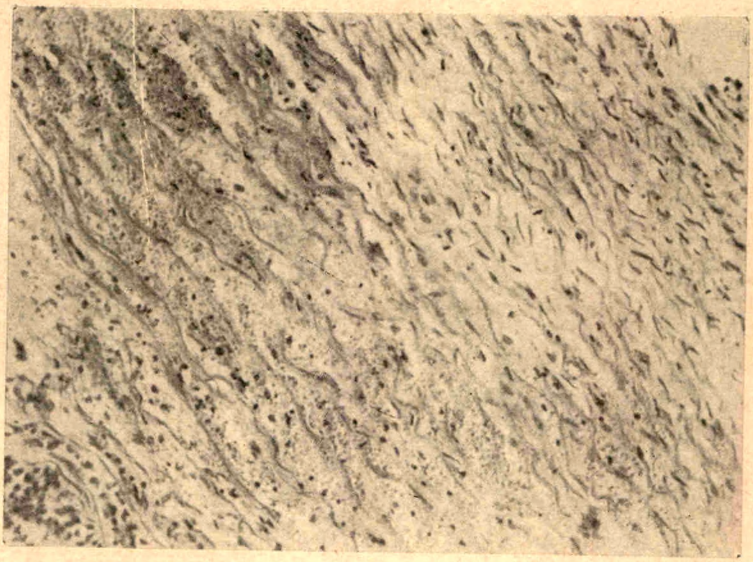

Fig. 5. Another section showing haemorrhage between fibrous bundles. x 170.

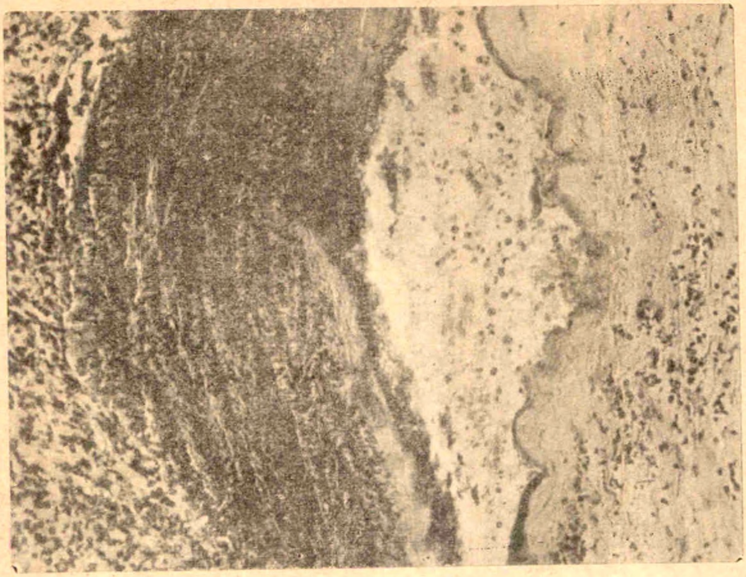

Fig. 6. Portion of a section showing a continuous belt of eosinophils. x 170.

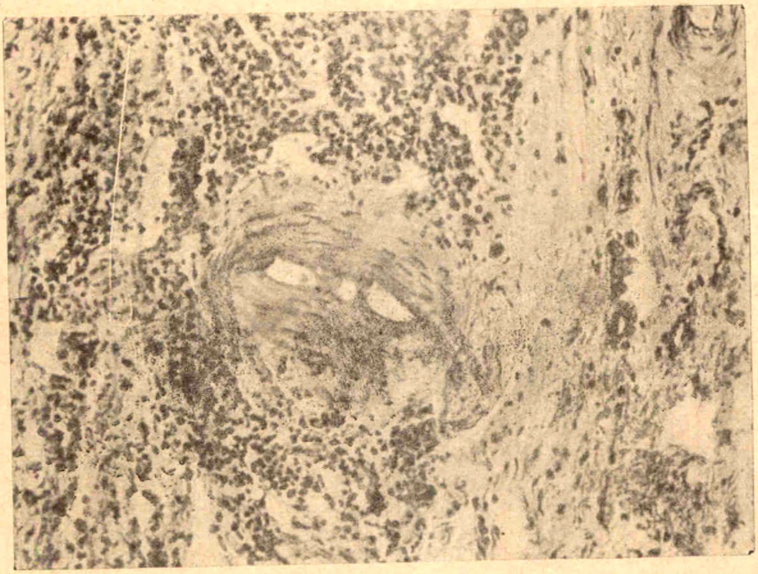

Fig. 7. Portion of another section showing thickened blood vessels in tunica adventitia. x 220.

STUDIES ON THE ACTION OF DRUGS ON MICRO-ORGANISMS* (*ESCHERICHIA COLI* AND *SACCHAROMYCES CEREVISIAE*)

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The problem of the action of drugs and antibiotics on micro-organisms, resulting in either mutated or adapted strains has assumed a major importance in the field of industrial fermentations, Biochemistry and medicine. When a drug is added in the medium of a micro-organism, its growth shows a different pattern of the curve than the growth in drug free medium, *i.e.*, the slope of the growth curve falls with the increase of drug concentration. Ultimately at a certain concentration there is no growth. This concentration is called the lethal dose of a micro-organism. If a constant population of a micro-organism is passaged by sub-culturing through the medium containing increasing quantities of the drug, a resistant culture is developed which can tolerate higher concentrations of the drug far in excess to its lethal dose. This resistant culture shows different pattern than the parent culture. In the present thesis, an attempt has been made to study the few properties of the resistant strain and the stability of the resistance thus developed with the uninvestigated drugs and their mode of action has been correlated with the existing knowledge.

Part I of this thesis deals with the studies on the action of drugs (stylomycin, viomycin and oleandomycin) on *Esch. coli.*

(a) *Growth characteristics*—If a micro-organism is allowed to grow in a medium containing sublethal doses the pattern of growth is changed. Thus the kinetics of the growth of *Esch. coli* under the action of stylomycin and viomycin has been followed by withdrawing the samples asceptically from time to time and noticing the turbidity developed with the Spekker absorptiometer. $K_{av.}$ (Average velocity coefficient), M.G.T. (Mean generation time) and tan θ (slope of the growth curve) have been calculated to characterise the drug action. As a result of the action of drugs the $K_{av.}$ and tan θ fall and M.G.T. increases when compared with the growth of parent culture in drug free medium. The inhibition is thus a function of drug concentration.

As a result of passaging the parent culture through the increasing concentrations of the drugs, a resistant culture is developed. Stylomycin resistant culture shows slightly lower values of $K_{av.}$, M.G.T. and tan θ in drug free medium as well as in medium containing sublethal doses of the drug, therefore, these values appear to be independent of drug concentrations. The values of $K_{av.}$, M.G.T. and tan θ, fall to the extent of 50% in viomycin resistant culture.

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* Abstract of the thesis submitted to the Agra University for the degree of Doctor of Philosophy.

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If this resistant culture is sufficiently passaged through the drug free medium the values of $K_{av.}$, M.G.T. and tan θ approach towards those of the parent culture in drug free medium and so it appears that the training is being lost. These values show that the stability of the training is quite high in case of viomycin *i.e.*, even after 60 passages through the drug free medium, the culture did not return to the normal.

On plating the trained (resistant) culture and comparing the size of colonies by the resistant culture and the normal culture, it is observed that the colonies size of the trained culture is sufficiently small, although no data could be reported about this behaviour in the present thesis.

(b) *Respiratory studies*—Warburg respirometers have been used for this study. The direct method described by Umbreit *et al*[1] of estimating oxygen consumption and carbondioxide evolution has been used. It is observed that both are depressed by the action of sublethal concentrations of viomycin and stylomycin on the parent culture. The resistant culture to these drugs also shows depression in oxygen consumption and carbondioxide evolution when compared to the parent culture in drug free medium. If the sublethal doses are supplemented in the medium the rate of oxygen absorption and carbondioxide evolution is accelerated than the trained culture in drug free medium. This behaviour shows that as a result of training the organism acquires a property of treating the drug as its essential metabolite. This behaviour is also observed by the reversed strains.

(c) *Enzymatic studies*—The activity of catalase, glucosedehydrogenase, glutamic acid decarboxylase and pyruvic acid decarboxylase as well as acid production and pH fall by the resistant and normal culture have been studied.

The catalase activity has been estimated directly by titration of hydrogen-peroxide by $KMnO_4$. The training to stylomycin produces no effect on the catalase activity of *Esch. coli*. The catalase activity is very high in viomycin resistant culture, when compared to the parent culture. If the resistant culture to viomycin is passaged through the drug free medium the catalase activity tries to return to the normal showing that the training is gradually being lost by passaging through the drug free medium.

Glucose dehydrogenase activity has been estimated by Thumberg technique[2] by noticing the reduction of the colour of methylene blue with the Klett's photoelectric colorimeter. The glucose dehydrogenase activity in case of viomycin resistant culture is the same as that of the parent culture, but it falls in case of stylomycin resistant cultures.

Glutamic acid decarboxylase activity has been estimated by Warburg respirometers as described by Umbreit *et al.*[3] The activity falls in stylomycin, oleandomycin and viomycin resistant culture as compared to the activity of the parent culture. The fall is more (approximately 50%) in viomycin resistant culture, The pyruvic acid decarboxylase activity has been estimated using Warburg respirometers as described by Umbreit *et al.*[4] This activity falls in stylomycin, oleandomycin and viomycin resistant cultures when compared to the parent culture. This fall is more in viomycin resistant culture.

The pH fall has been determined on a pH meter and the acidity developed is titrated by 0·01N NaOH. The fall in pH and acid production in case of stylomycin resistant culture is nearly the same as that of the parent culture. But the fall in pH and acid production is less in case of viomycin resistant culture than the parent culture.

(d) *Studies on RNA., DNA and Protein precipitation*—RNA has been estimated by Orcinol reagent[5] and DNA by Diphenylamine reagent[6] method, in the cell free extract from parent culture and resistant cultures to stylomycin and viomycin. DNA is less in stylomycin resistant culture and RNA in viomycin resistant culture.

The protein precipitation has been followed by noticing the turbidity developed in the protein by the addition of the drug. 0·1% protein from the cell free extracts of normal culture was treated with the varying concentrations of stylomycin and viomycin and the concentration where maximum precipitation occurred noted by noticing the turbidity on Spekker absorptiometer. In the same way the precipitation was effected by stylomycin in cell free extracts from stylomycin resistant culture and by viomycin in cell free extracts of viomycin resistant culture. It is observed that as a result of training the precipitation values of proteins are increased *i.e.*, protein from the trained cells require more drug to precipitate the total protein, than the protein from the parent culture. This behaviour supports the view that on training some adaptative enzymes are developed which can tolerate higher concentrations of the drug.

(e) *Electrophoretic studies*—Electrophoretic studies on the cell free extracts from parent culture and the resistant cultures to stylomycin and viomycin have been carried on the Tiselius Electrophoresis apparatus model 38A (Perkin Elmer Corporation U.S.A.). The ionic mobilities of the components from the trained cultures are different than the parent culture.

(f) *Antagonising effect of amino acids*—The antagonising effect of various amino acids, on the parent culture in presence of sublethal concentrations of the drugs have been studied. No amino acid could be proved as antagonising agent on the proposed drugs.

The viomycin trained strain has been grown in presence of various amino acids. The glutamic acid was the only amino acid that gave some response on the reversal of the training.

Part II of this Thesis deals with the studies on the action of drugs on yeast (*Saccharomyces cerevisiae*).

(a) *Glucose Assimilation*—Intra and extra cellular carbohydrates of yeast proliferating in the medium containing cerfak and gentian violet have been determined by the method of Fales.[7] Both intra and extra cellular carbohydrates show fall with increase of drug-concentration when compared with the normal culture.

As a result of training to gentian violet and plating of this culture, two types of colonies develop. The colonies which appeared first are called primary and those which appeared after four or five days of incubation as pin point colonies or secondary colonies.[8] The secondary colonies show less intra and extra cellular carbohydrates than the primary colonies.

(b) *Pyruvic acid decarboxylase activity*—It has been estimated in the cell free extracts from the normal culture, primary colonies and secondary colonies using Warburg respirometers as described by *Umbreit et al.*[4] The pyruvic acid activity is nearly the same in primary and secondary colonies but this activity is less when compared with the parent culture of yeast.

(c) *Studies on RNA of yeast*—When yeast cells are grown in presence of cerfak the RNA values increase during the period of lag phase and this increase is more with increase of cerfak concentration. Finally the RNA content falls and the fall is more with the increase of cerfak concentration. During the lag phase the cell division is stopped and by the addition of cerfak this lag period is enhanced, therefore, for further growth more RNA has to be synthesized. Therefore, in case of higher cerfak concentration more RNA has to be synthesized for further growth.

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KINETIC STUDY OF THE OXIDATION OF ALDEHYDES, KETONES AND OTHER RELATED COMPOUNDS BY PERSULPHATE ION*

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The present work deals with a systematic kinetic study of the Ag. catalysed oxidation of some aliphatic ketones, of aliphatic aldehydes and of iso—propyl alcohol by potassium persulphate in aqueous medium. During recent years the kinetic study of oxidation of different organic compounds by persulphate ion has been carried out by a number of workers, but the Ag˙ catalysed reactions have not been investigated systematically. My aim of the present study has been to find out whether the oxidation of these simple ketones, aldehydes and alcohols follow a similar type of behaviour or not and to investigate the nature of the oxidation product formed in each case.

The results obtained in the Ag˙ catalysed oxidation of acetone, methyl-ethyl ketone, di-ethyl ketone, methyl-n propyl ketone and of methyl-iso-propyl ketone by $K_2S_2O_8$ may be summarised as follows:—

(i) The uncatalysed reaction is very slow, but the Ag˙ catalysed reaction has a measurable rate at 35°C, the over—all order of the silver catalysed reaction has been found to be one, it being unimolecular with respect to $K_2S_2O_8$ and zero order with respect to ketone. The rate is linearly related to the $AgNO_3$ concentration. However, the unimolecular constant generally decreases slightly with time in any individual run which has been traced by me due to the increase in ionic strength as the reaction proceeds. At constant ionic strength the unimolecular rate constant does not decrease with time.

(ii) The reaction in each case exhibits a negative salt effect of the primary exponential type.

(iii) The rate is found to be almost independent of H˙ ion concentration, while Na˙ and K˙ ions have specific inhibitory effect, the effect of potassium ion being greater than that of sodium ions.

(iv) The rate constant decreases as we pass on from acetone to higher members of this homologous series.

The mean value of rate constant, temperature coefficient, energy of activation, frequency factor and entropy of activation for each reaction are given later on.

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In the case of Ag˙ catalysed oxidation of aldehydes by persulphate ion, it was found by me that the results in the case of formaldehyde oxidation are rather erratic and reproducible results could only be obtained with the same stock solution. However, the reaction in this case, as well as in the case of acetaldehyde and propionaldehyde was found to be unimolecular, being first order with respect to potassium persulphate and almost zero order with respect to the aldehyde. The uncatalysed reaction in this case is also very slow, about 1/10th reaction taking place in 6 hours at 45°C in the case of formaldehyde oxidation. The rate for the Ag˙ catalysed reaction is, here again, linearly related to the silver nitrate concentration. In the case of formaldehyde reaction, the rate constant is found to increase with an increase in the initial concentration of potassium persulphate while it decreases with an increase in HCHO concentration. The salt effect in each case is negative, the exact nature of this negative salt effect could not be determined in the case of HCHO reaction, but in the case of CH_3CHO and C_2H_5CHO reaction, this negative salt effect is found to be of primary exponential type. The rate for CH_3CHO reaction is found to be much higher than that of HCHO or C_2H_5CHO reaction. In the case of CH_3CHO and C_2H_5CHO reaction there is an induction period, in the former case at high salt concentration while in the latter reaction at high concentration of propionaldehyde.

The uncatalysed oxidation of iso-propyl alcohol by potassium persulphate was investigated both in non-buffered medium and in buffered medium at a pH of 7·96. It was found that although the reaction is unimolecular, but the rate constant value increases with an increase in potassium persulphate concentration and after a certain concentration of potassium persulphate it becomes approximately constant. The behaviour of this reaction is similar to that found by Levitt and Malinowski[1] for this uncatalysed reaction in the buffered medium. But in the case of Ag˙ catalysed reaction the rate constant was found to decrease with an increase in potassium persulphate concentration and this decrease became very small at higher concentration of potassium persulphate. Further it was found by me that the rate constant decreased with time in any particular run which has been shown by me due to the increase in H˙ ion concentration as the reaction proceeds and not due to the SO_4'' as suggested earlier by Levitt[2] for such reactions. The rate constant both for the uncatalysed as well as for the Ag˙ catalysed reaction was found to increase with increase in alcohol concentration and became constant after a certain alcohol concentration. The same result was observed in the case of uncatalysed reaction by Levitt and Malinowski.[3] The salt effect for the Ag˙ catalysed reaction was found by me to be negative and of the primary exponential type. Levitt and Malinowski (loc. cit.) have proposed a mechanism for this uncatalysed reaction wherein they first supposed the heterocyclic dissociation of S_2O_8'' ion into SO_4'' and a molecule of sulphur tetroxide (SO_4) as the primary process and this SO_4 radical was then supposed to attack the alcohol molecule to form the intermediate complex which then decomposes to give the reaction product. In the later study they suggested a modification, namely, the formation of intermediate complex between alcohol and sulphur tetroxide radical without supposing a prior dissociation of S_2O_8'' ion. This mechanism has been very recently criticized by Ball, Crutchfield and Edwards[4], who have supposed the decomposition of S_2O_8'' ion into two sulphate radical ions (SO_4') as the primary process and the SO_4' radical ion is supposed to act as the oxidising species, attacking the alcohol molecule in the subsequent steps. However, my work is mainly concerned with the $Ag^{\cdot}$ catalysed reaction and as such obviously a different mechanism will be operative.

I have isolated the oxidation product in each case and have applied spot tests for the detection of the different oxidation products. This investigation showed the presence of following oxidation products in the different reactions.

Acetone — Persulphate reaction —Acetic acid and formic acid.
CH_3-ethyl ketone — ,, ,, —formic, acetic and propionic acids.
Di-ethyl ketone — ,, ,, —acetic and propionic acids.
CH_3-n-pro. ketone — ,, ,, —formic, acetic, propionic and butyric acids.
CH_3-iso-pro. ketone — ,, ,, —formic, acetic, propionic and butyric acids.
Formaldehyde — ,, ,, —formic acid.
Acetaldehyde — ,, ,, —acetic acid.
Propionaldehyde — ,, ,, —propionic acid.
Iso-pro. alcohol — ,, ,, —acetone.

Thus it is seen that in the case of ketones, carboxylic acids with lesser no. of carbon atoms are formed, while in the case of aldehydes, carboxylic acid with the same number of carbon atoms is found which is the general rule.

The present study enables me to conclude that the $Ag^{\cdot}$ catalysed oxidation of ketones, aldehydes and iso-propyl alcohol by persulphate ion investigated by me follow a similar behaviour, as stated above and which is also evidenced by the compiled data of the following table.

TABLE I

Reductant	k unimolecular l. mol^{-1} min^{-1}	Mean temp. coeff.	E Energy of activation Kcals.	A Frequency factor litre mole sec.$^{-1}$	$\Delta S^{\dagger}$ Entropy of activation E.S.U.
Ketone — $K_2S_2O_8$ — 0·02 M; $AgNO_3$ — 0·0005 M					
Acetone	3·312	1·88	12·66	2·259$\times 10^4$	−38·15
Ethyl-methyl ketone	2·846	1·90	12·85	3·097$\times 10^4$	−38·15
Di-ethyl ketone	2·834	1·92	13·04	4·010$\times 10^4$	−37·65
Methyl-n-pro. ketone	2·751	1·94	13·34	6·279$\times 10^4$	−36·62
Methyl-iso-pro. ketone	2·647	1·88	12·75	2·311$\times 10^4$	−38·73
Aldehyde — $K_2S_2O_8$ = 0·01 M					
Formaldehyde ($AgNO_3$—0·0002 M)	27·521	1·99	13·02	1·118$\times 10^5$	−35·51
Acetaldehyde ($AgNO_3$—0·0001 M)	71·798	2·21	14·49	1·902$\times 10^6$	−29·89
Propionaldehyde ($AgNO_3$—0·001 M)	4·354	1·86	11·86	1·987$\times 10^4$	−38·99
Alcohol — $K_2S_2O_8$ — 0·02 M; $AgNO_3$ — 0·0004 M					
Iso-propyl alcohol	7·455	2·15	14·51	9·334$\times 10^5$	−31·32

Note—The value of the rate constant tabulated above are those obtained by dividing the observed rate constant by the concentration of silver nitrate.

Since the rate in each case has been shown to be linearly related to silver nitrate concentration, we may write :—

$$\frac{dx}{dt} = k_r \, C_{Ag^{\cdot}} \, C_{S_2O_8''} \qquad = kC_{S_2O_8''}$$

where k is the experimentally measured rate constant and is equal to the product of the absolute rate constant k_r and the $AgNO_3$ concentration.

The above data clearly show that the rate constant for the oxidation of ketones slightly goes down as we go up the homologous series but is of the same order, while the rate constant for formaldehyde and acetaldehyde oxidation is much higher but for propionaldehyde only slightly more than that for acetone while the constant for iso-propyl alcohol oxidation is more than doubled than that for acetone oxidation. However, one thing is remarkable that all these reactions have energy of activation of the same order ranging from 11·86 to 14·51 Kcals. mole^{-1}. Further more the entropy of activation for each reaction is negative and ranges from $-29{\cdot}9$ E. U. to $-38{\cdot}73$ E. U. These facts together with the similar nature of these reactions lead me to the conclusion that these reactions follow a common general mechanism. Taking into account the general features of these reactions, the most plausible mechanism seems to be

$$S_2O_8'' + Ag^{\cdot} \xrightarrow[\text{determining}]{\text{rate}} SO_4'' + SO'_4 + Ag^{\cdot\cdot} \qquad \text{(i)}$$

$$SO_4' + H_2O \xrightarrow{\text{rapid}} HSO_4' + OH \qquad \text{(ii)}$$

$$OH + Ag^{\cdot\cdot} \xrightarrow{\text{rapid}} Ag^{\cdot} + OH^{+} \qquad \text{(iii)}$$

$$OH^{+} + R \xrightarrow{\text{rapid}} H^{\cdot} + \text{oxidation product} \qquad \text{(iv)}$$

and also

$$SO_4' + R \xrightarrow{\text{rapid}} HSO_4' + \text{oxidation product} \qquad \text{(v)}$$

where R is the reductant. The above mechanism accounts for the unimolecularity of the reaction with respect to S_2O_8'', the linear dependence of the rate on $Ag^{\cdot}$ and independence of the rate of the concentration of the reductant. Further the negative salt effect of the primary exponential type is accounted for. This mechanism, it may be pointed out, is on the lines of the general mechanism proposed by Srivastava and Ghosh[5] for the $Ag^{\cdot}$ catalysed reactions.

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STUDIES ON THE VEGETATIVE GROWTH AND DEVELOPMENT OF MALE AND FEMALE GAMETOPHYTE IN AONLA (*EMBLICA OFFICINALIS* GAERTN.)

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Aonla (*Emblica officinalis,* Gaertn.) which was till recently known as *Phyllanthus emblica,* belongs to the family Euphorbiaceae, sub-family Phyllanthoideae. It is more popular in Uttar Pradesh and is largely cultivated in the districts of Azamgarh, Pratapgarh, Varanasi and Bareilly. Aonla trees have also been reported from Cuba, Puerto Rico (Williams and Williams, 1951), Hawaii (Neal, 1948).

Pillay and Mahadeva (1958) are of the opinion that the fruit is not only a rich but also the cheapest source of vitamin C. It is valued as an antiscorbutic and for treatment of digestive and other disorders. It is one of the constituents of "Triphala" the well known general indigenous medicine for several diseases of the stomach and eye.

Although the aonla fruit is of great economic importance and possesses a considerable nutritional value, no attempt has been made by the research workers to make even such basic information available as on its growth, floral biology, bearing habits etc. Even in the western hemisphere it has remained a horticultural stepchild for the last 60 years.

Before any improvement programme is taken upon aonla, it is necessary to fill up this gap in our knowledge which has stood in the way of increased acreage and production of this supreme fruit. The present investigation was, therefore, undertaken to have a detailed information on (a) growth habit, (b) fruit bud differentiation and (c) development of male and female gametophyte.

MATERIAL AND METHOD

Four aonla trees of the variety 'Banarsi' of uniform age, size and vigour were selected for the present study. These trees are growing side by side in the Botanical Garden, Government Agricultural College, Kanpur They were about 20 years old and had received a uniform treatment as regards manuring and irrigation from the time of their planting. Each tree was divided into four parts and observations were recorded on branches radiating in these directions.

Emergence of new branches:

In order to determine the total number of new shoots emerging in different months during the season, observations were recorded only on two trees. At the end of each month, all the new shoots were counted and these observations were continued until the emergence of new shoots ceased. The total number of shoots produced in the year was calculated by adding the number of monthly shoots that emerged during the season.

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* This paper is a part of the thesis submitted to the Agra University for the award of the Ph. D. degree.

Measurement of new shoots:

The new vegetative shoots were tagged on each tree and their measurement was recorded in centimeters during the period from April to August in the years 1960 and 1961. Thus a total of 40 branches were measured at weekly intervals.

Blossom but differentiation:

Young buds soon after their appearance on the old branches were collected at weekly intervals during the period commencing from 28th February to 8th April in both the years 1960 and 1961. They were fixed and killed in formalin-aceto-alcohol (70%) to determine the time and duration of blossom bud differentiation.

In 1961, pistillate flowers were collected separately from the bud stage to 3 days after anthesis for the study of megagametophyte.

These materials were dehydrated by tertiary-butyl-alcohol method of Johansen (1940), embedded in paraffin wax and sectioned on a rotary microtome at 8 to 15 micra. Sections were stained in Safranin 0 and fast green, crystal violet and iron-alum haematoxylin. The schedule followed was after Maheshwari (1940).

VEGETATIVE STUDIES

(a) *Time of emergence of vegetative shoots:*

The new vegetative shoots emerged as lateral growths on those branches which had broken or whose apices had aborted in the previous growing season. They began to emerge from the month of March after the leaf and branchlets shedding was completed. The new shoots arising in each month were counted on the trees under observation and the data are presented in Table 1.

TABLE 1

Average number of vegetative shoots emerging from an aonla tree in different months.

Year	No. of shoots and average temperature in °C per month									
	March		April		May		June		July	
	No. of shoots	Temp.	No. of shoots	Temp.	No. of shoots	Temp.	No. of shoots	Temp.	No. of shoots	Temp.
1960	6	30·7	15	38·0	44	42·0	11	40·6	1	32·8
1961	7	32·8	14	39·1	41	41·8	16	38·2	3	33·8

The data in Table 1 show that the new branches appeared from March to July but the maximum number of branches emerged in the month of

May in both the year just after the flowering was over. No vegetative shoots appeared after July and the number of shoots which emerged in July was insignificant.

(b) *Extension growth of vegetative shoots:*

With a view to find out the period of cessation of growth in aonla, periodical measurements of new branches were taken. These measurements were started from the 1st and 2nd week of April in the year 1960 and 1961 respectively and were continued till the 2nd week of August in both the years. The data are presented in Figure 1.

It is apparent from Figure 1 that the vegetative growth continued from first week of April to 2nd of August in the year 1960 while in the year 1961, it lasted between 12th April to 9th August. It is also obvious from the figure that in both the years, the linear growth of the vegetative shoots was very vigorous between April and 2nd week of June and after that the extension growth slowed down and it completely ceased in August. Thus there was only one cycle of growth in aonla and the trees did not make any vegetative growth after August. It was also observed that the apical growing points of most of the shoots either dried or aborted by the end of July and thus, these branches did not make any linear growth next year but instead new vegetative shoots appeared from these injured portions laterally.

(c) *Leaf fall and emergence of new branchlets:*

Aonla, not only begins to shed its leaves but also its branchlets from 1st week of February and by the third week of March the tree is quite bare of leaves and branchlets (Figure 2 A and B). The process of leaf fall is slow in the beginning but in March it is very rapid. In the month of February slender branchlets emerged as knob like buds by the side of the last season's abscissed branchlets, after 21 days of their abscission (Figure 2C). But on those branches where the leaf and branchlets shedding was completed by 19th of March, the new buds which developed into small branchlets appeared only 5 days after the abscission of old branchlets. Later these vegetative buds flattened (Figure 2D). Small floral buds appeared on those young branchlets by the middle of March. Thus the abscission of branchlets and leaves is a pre-requisite for the appearance of blossoms on aonla trees.

BLOSSOM BUD DIFFERENTIATION

(a) *Time of blossom bud differentiation:*

The time of floral initiation has been determined in many species of cultivated fruit trees but less is known regarding the time of fruit-bud differentiation in aonla. Young aonla buds were, therefore, collected during the period from 28th February to 8th April at weekly intervals to study the time and mode of blossom bud differentiation. By 8th April floral buds were visible on all the young slender branchlets all over the tree hence collection of buds for the study of blossom bud differentiation was stopped.

The data regarding its duration are presented in Table 2.

TABLE 2

Duration of blossom bud differentiation in aonla

Date of collection of buds in 1960	No. of buds examined	No. of buds differentiated	Average temperature of the week in centigrade
February 28	10	...	27·7
March 6	10	2	28·3
March 12	10	6	28·6
March 18	10	9	29·1
March 24	10	7	31·2
March 31	10	10	32·4
April 8	10	10	33·2
April 16	No buds were available		33·6

It is clear from Table 2 that blossom bud differentiation commenced from 6th March and the buds continued to differentiate till April 8, in the year 1960. In the year 1961 also the trend of blossom bud differentiation was nearly similar to that of the last year. Thus March can be taken to be the period of blossom bud differentiation in aonla and it lasted for 32 days. During this period the average maximum temperature ranged between 27·7° to 33·2°C.

Longitudinal sections of the buds collected on February 28, 1960, did not show any sign of differentiation of floral parts (Figure 3) in the axil of leaf primordia. However, a proliferation of differentiated cells in the axil of leaf primordia was observed in the sections of buds collected on March 6 (Figure 4). These protuberances are the primordia of bracts. These bracts are caducous in nature and are rarely seen in a fully developed inflorescence. Later on, at the lower end of the longitudinal section, a club shaped structure with two undulations on it was seen (Figure 5). This is the first indication of blossom bud differentiation and the undulations are the initiations of perianth primordia (Figure 6). Thus the floral bud arises as a club shaped structure and at one time three buds are seen (Figure 5), covered with two bracts in the axil of a leaf. The central bud was first to emerge and so is bigger than the rest of the two which have yet to assume the club shaped form. By this time, the vegetative buds had flattened externally and attained a size of 0·6 centimeter. Thus it took 6 days for the young bud to initiate flower primordia and reach this advanced stage when the floral organs started to differentiate. Blossom bud differentiation followed vegetative growth.

All the floral buds in the leaf axil, however, did not differentiate at one time but showed different stages of differentiation and development. Thus the floral differentiation in aonla was a continuous process.

(b) *Ontogeny of male flower:*

L.S. of developing branchlets of varying ages were cut to study ontogeny of a male flower. L. S. of the male flower (Figure 6) shows the initiation of Ist whorl of the perianth leaves. They arise as lateral outgrowths. The second whorl of perianth arises after 3 or 4 days from the side of the first whorl of perianth (Figure 7). Simultaneously the central mass differentiates into stamens (Figure 8). Thus the development of the floral parts is in acropetal succession. By this time, the floral buds appeared on the branchlets and could be discerned by the naked eye.

(c) *Micro-sporogenesis and Male Gametophyte:*

In a cross section the pre-archesporial anther is a homogenous mass of parenchymatous cells covered by an epidermis (Figure 9). The anther appears four lobed in cross section at an early stage of development and a plate of archesporial cells defferentiates in each lobe, distinguished from the adjacent cells by their larger size and large nuclei (Figure 10).

The anther wall consists of epidermis, hypodermis, one or two middle layers and a uninucleate tapetum (Figure 11), which encloses young microspore mother cells. The hypodermis as usual forms the fibrous endothecium (Figure 12). The microspore mother cells divide to form tetrads and by this time the middle layers disintegrate. The young pollen grains are arranged either in a tetrahedral or isobilateral forms but most common arrangement is the tetrahedral. As soon as the tetrads are formed, the tapetum also shows signs of disintegration. When released from the tetrad, the microspores are angular and uninucleate and by this time the tapetum further degenarates. Because of the disintegration of the tapetum and surrounding cells, the pollen sac is only partially filled with pollen. At this stage exine and intine are differentiated and the intine soon becomes thick but the exine remains thin. Later on, due to the dissolution of the separating walls, the four pollen sacs fuse to form two loculi (Figure 13). There is no trace of any tapetal remains when the pollen grains reach maturity. Gametogenesis is completed prior to dehiscence of the anther and the pollen grains are shed in the two celled condition.

(d) *Megasporangium and female gametophyte:*

Ovule—The ovary is trilocular with two anatropous ovules in each locule which hang from the axile placentation into the ovarial cavity (Figure 14). In the early stage of the development of the ovule; the nucellus protrudes out of the two integuments and forms a beak with a knob (Figure 15). As the ovule grows in size the beak also grows and finally establishes contact with the obturator and thus there is no true micropyle in the aonla as has been reported in other members of this family.

The ovary is enclosed in a ridged receptacle which is known as 'Cupule' (Figure 14).

The nucellus is composed of compact parenchyma. The outer integument is two layered except at the micropylar end where it is massive and the inner integument is three layered (Figure 16). The cells of the inner epidermis of the inner integument are filled with brown contents as reported in *Phyllanthus niruri* (Singh, 1960).

Female gametophyte—On the day of anthesis, the megaspore mother cell nearly lies at the approximate centre of the ovule (Figure 17A), in preparation for division. It gives rise to a row of four megaspores, the outer three of which degenerate (Figure 17B). The chalazal megaspore enlarges and the first nuclear division gives rise to two nuclei which move apart and a much larger vacuole forms in the mid-portion of the cell (Figure 17C). Both daughter nuclei now divide to give a four-nucleate cell (Figure 17D). The nuclei are located in the peripheral layer of cytoplasm, two being at each end of the cell. Each nucleus of the sac then undergoes the final division to form eight nuclei but very rarely an eight nucleate stage is met with because the antipodals degenerate very early. Therefore, only four or five nucleate embryo sacs are usually observed (Figure 17E). Thus a typical eight celled macrogametophyte is formed which consists of 3 small antipodal cells at the chalazal end, three large cells, the egg apparatus, at the micropylar end and two polar nuclei at or near the centre of the sac. Numerous starch grains are present in the embryo sac.

The egg apparatus consists of three pear-shaped cells, the egg and two synergids. The egg is somewhat larger than either of the synergids. The nucleus of the egg which is much larger than those of the synergids lies in the basal portion of the cell.

The embryo sac is typical of a monosporic eight-nucleate embryo sac of the polygonum type.

DISCUSSION

The new vegetative shoots appeared on the aonla trees towards the end of March and they continued to emerge till the beginning of July. During this period the branches made a rapid extension growth but by the second week of August the growth of the branches ceased. Thus it seems that a warm and dry weather is favourable for the vegetative growth in aonla. It was also observed that by this time the apices of the new vegetative shoots had either dried or aborted. Bui and Nguyen (1962) also reported that the shoot apices of *Citrus sinensis*, *C. nobilis*, *C. limonum* and *C. decumana* were shed after extension growth stopped although shoot thickening and leaf expansion continued. Generally during this period of the year, the average maximum temperature ranged between 38° to 42°C, and there was no vegetative growth when the temperature dropped below 30°C. Krishnamurthi, Randhawa and Nair (1961) who carried out growth studies on mango varieties Dashehari and Chausa, concluded that most extension growth was made during mid-March to May. Similar observations have been made by Bajpai and Maurya (1963) in Kaitha (*Limonia acidissima*) which also makes vegetative growth in the summer months. In citrus Krishnamurthi *et al* (1960) reported that the temperature plays an important role in the production of new vegetative growth. They observed that there was no growth in citrus when the temperature was below 13·6°C, and the maximum growth took place, at a temperature range 18-24°C. Motial (1962) also recorded highest percentage of vigorous shoots in the May-June flush in various species of citrus which he studied.

In mango, the optimum temperature for vegetative growth under Delhi conditions has been found to be between 24 and 28°C. Although no published records are available in case of aonla in this regard, the present studies have clearly shown that a temperature range of 30·7-42°C., is quite conducive for growth in aonla.

The criterion of blossom bud differentiation in the present investigation was the flattening of the apical meristem with two lateral protuberances one on either side of it as reported in citrus by Abbot (1935) and Randhawa and Dinsa (1947), and in mango by Singh (1958).

Blossom bud differentiation was first observed on the sixth of March in the buds which had initiated after the fall of old branchlets in February or even earlier and the differentiation of floral buds continued till the lst week of April. By this time all the new branchlets had emerged. The floral buds appeared mainly on the current season's branchlets and so it seems that the abscission of old branchlets is a pre-requisite for the emergence of new branchlets and consequently for blossom bud differentiation. During March the maximum temperature ranged between 29·3 to 34·6°C., in the year 1960. So it appears that a warm season was conducive for the initiation of floral buds. It has been also observed in *Aegle marmelos* (Tewari, 1962) and in *Limonia acidissima* (Bajpai and Maurya, 1963), that blossom bud differentiated after the trees had shed their leaves in the month of March and April and during this period the temperature ranged between 32·8 to 39·1°C. In citrus also, it has been reported by Abbot (1935), Singh and Dhuria (1960) that differentiation in sweet lime took place with the commencement of new growth. In mango the time of differentiation of the flower bud is reported to be the month of October in Florida (Sturrock, 1934; Mustard and Lynch, 1946), whereas in India October and first half of November are reported to be the time of flower bud differentiation under Sabour (Bihar) conditions (Sen and Mallik, 1941) and December under Saharanpur conditions (Singh, 1958). Thus it seems that temperature influences the time of blossom bud differentiation and aonla being a tropical fruit requires slightly warmer conditions for fruit bud differentiation.

Most of the deciduous fruit trees, for example, apple pear, plum and cherry, initiate blossom buds during May and June following their period of vegeta'ive growth in the spring. In aonla blossom bud differentiation is a continuous process, as reported in mango (Singh, 1958), Loquat (Bajpai and Shukla, 1962).

There is no true micropyle in aonla as the nucelus protudes outside the integuments. Banerji and Dutt (1940) and Singh (1956) also reported that *Phyllanthus niruri* which belongs to the genus Phyllanthoideae does not have a true micropyle.

The obturator was observed to hang over the knobbed beak of the nucellus and it seems it helped in the pollen tube growth. Maheshwari (1952) also pointed out that the obturator is commonly present in the family Euphorbiaceae and it helps in the course of the pollen tube and is thus useful in bringing about fertilization.

The ovulate flower is enclosed by a cup shaped receptacle or 'cupule'. Though the general definition of a cupule is "an involucre of bracts adhering by their base" but in aonla it is not to be regarded as an involucre of bracts but rather a specialised stem or receptacle as reported in *Jugalance maundshurica* (Langdon, 1934) and in pecan (Shuhart, 1932). In aonla the cupule encloses the carpels and the perianth surrounds the cupule. After the abscission of perianth segments, the cupule which is thick and ridged, encases the ovary until middle of August when the fruit begins to swell and develop. At this time, the cupule splits due to the pressure of the growing fruit and it seems that the cupule plays an important role in protecting the fertilized ovary against the adverse weather conditions when it is not growing *i.e.*, in the months of April, May, June and July. By this device, the ovary escapes desiccation and external injury and thus the presence of a cupule in ovulate flowers is of great significance to a developing aonla fruit.

The development of the embryo sac is typical of monosporic eight nucleate embryo sac of the Polygonum type but generally a five nucleate embryo sac is met due to early degeneration of the antipodal cells as reported in *E. heterophylla* (Maheshwari, 1942). The nucellar neck is present from the very beginning and persists until the seed is almost mature.

SUMMARY

Studies on the bearing habit of aonla (*E. officinalis*) var. Banarsi including blossom biology and fruit set were conducted at the Botanical Garden, Govt. Agricultural College, Kanpur, during the years 1960-1962, and the salient features of the present investigations are presented here.

The new vegetative shoots began to emerge in the last week of March and they continued to appear till July. Mostly these branches arose as

lateral growths on the branches which had been injured or broken in the previous season. The growth rate was quite rapid between April and second week of June and on an average the weekly growth was 8·8 cm. After this, the rate of linear growth fell down and finally it ceased by second week of August. The trees were dormant between August and February. There was no growth extension in these branches next year because the apices aborted or dried by the end of July.

The trees began to shed their branchlets as well as leaves from February onwards and by the third week of March they were quite devoid of foliage. New branchlets emerged at nodes from the side of the scar left after the abscission of previous season's branchlets. They began to appear from the third week of February and continued to emerge till the first week of April. These branchlets appeared on all the branches irrespective of their age. The process of shedding of branchlets overlapped with the appearance of new branchlets on the naked branches.

Blossom buds appeared on these young and slender branchlets Abscission of old branchlets seemed a prerequisite for the emergence of new branchlets and consequently for blossom bud differenciation. Flower bud differenciation was noticed on March 6, in the year 1960 and it continued for 32 days. The development of the floral bud was a continuous process.

The floral parts of the male flower arose in acropetal succession and the development of the male gametophyte was normal. The anther wall consisted of epidermis, fibrous endothecium, one to two middle layers and a tapetum. The arrangement of young microspores was tetrahedral and the pollen grain were shed at the bicelled stage.

The development of the female gametophyte was normal of the monosporic Polygonum type and there was no true micropyle as the nucellus protruded outside the integuments and formed a knobbed beak. The obturator was observed to hang over the nucellus beak from the placenta. Placentation is axile and the ovary is trilocular with two ovules in each locule. Some time it shows a tetralocular condition.

ACKNOWLEDGEMENT

The author expresses his warm thanks to Dr. R. N. Singh, Horticulturist, I. A. R. I., New Delhi, who supervised this work.

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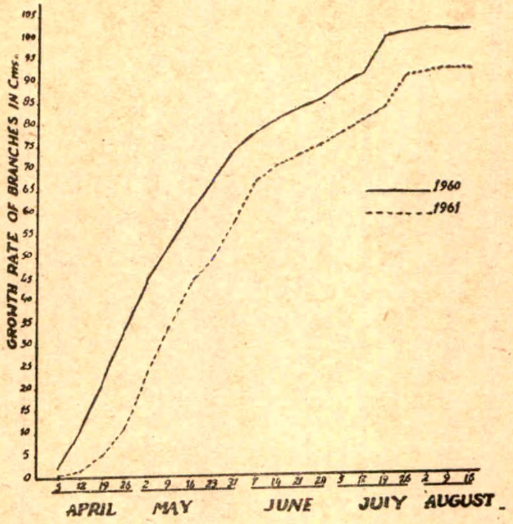
* Original not seen.

Fig. 1 LINEAR GROWTH OF AONLA BRANCHES IN Cms. IN APRIL, MAY, JUNE, JULY & AUGUST DURING THE YEARS 1960 -61.



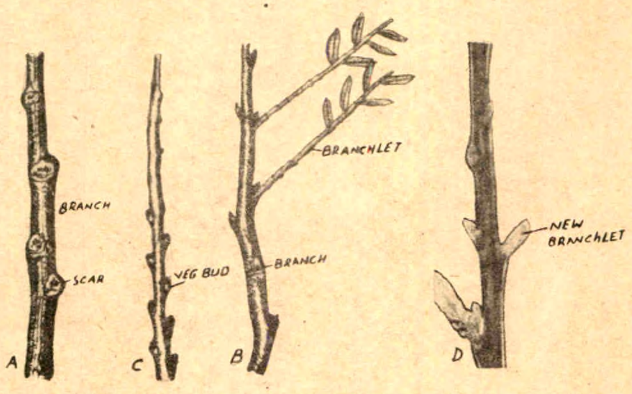


Fig. 2. A, a branch after leaf and branchlet shedding; B, a branch with leaves and branchlets about to shed; C, new vegetative buds arising from the side of the abscissed branchlets; D, vegetative bud flattening.

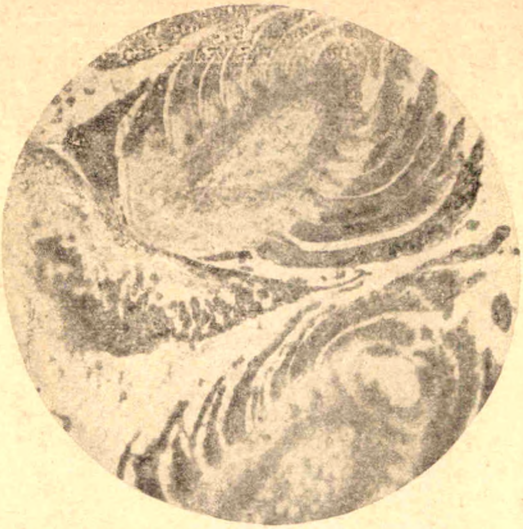


Fig. 3. Purely vegetative bud (branchlet) with leaves primordia (x25).

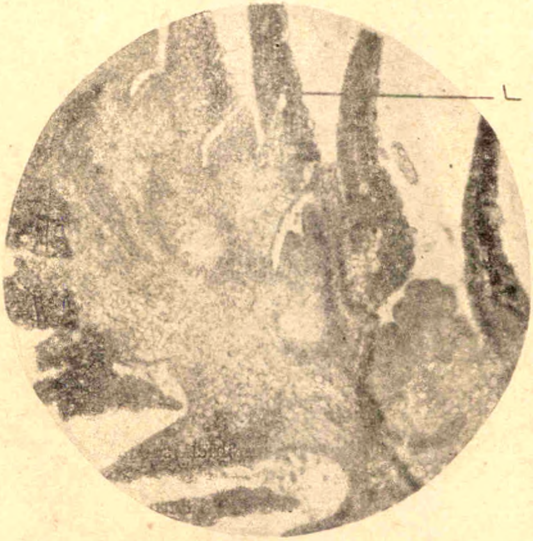


Fig. 4. Proliferation of the cells in the axil of leaf (L.) primordia at the upper end of a branchlet. x45 (Predifferentiated stage).

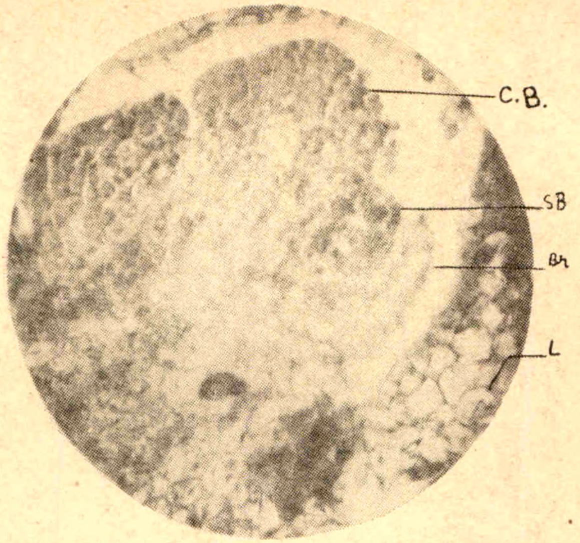


Fig. 5. A differentiated floral bud with two undulations in the centre and on its sides are two more floral primordia. All the buds are enclosed by two bracts. x75. (Br=Bract, C. B=central bud, S. B=side bud, and L=Leaf primordia).

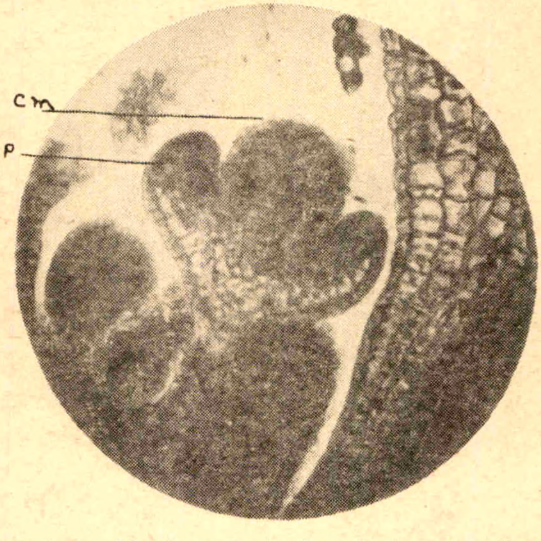


Fig. 6. Male floral bud with first whorl of perianth primordia. x65 (P=perianth primordia, c. m.=central mass).

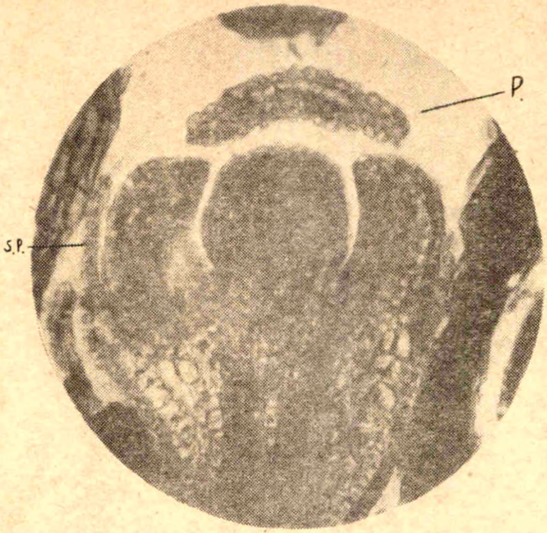


Fig. 7. Fully developed first whorl of perianth leaves and second whorl arising from the side of first one. x65. (S.P.=Second whorl of perianth primordia.)

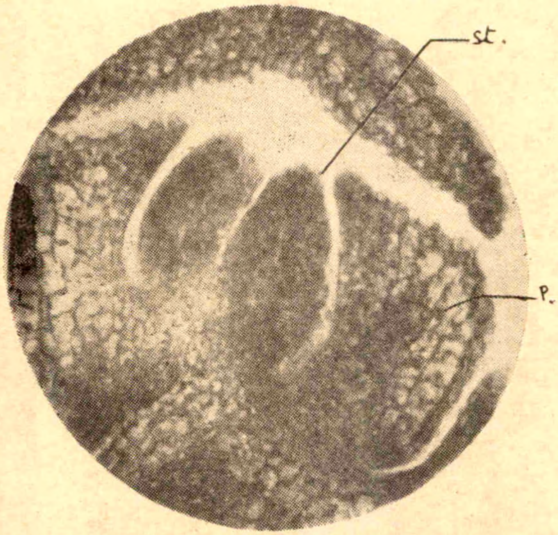


Fig. 8. Central mass of the floral bud differentiating into stamens. x45. (St=Stamens)

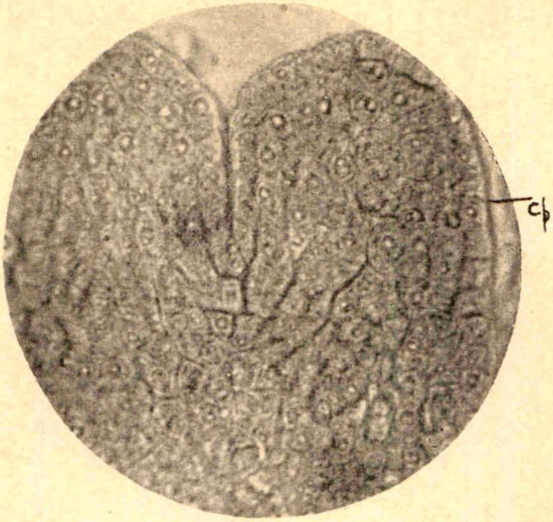


Fig. 9. A pre-archesporial anther with homogenous mass of parenchymatous cells covered with epidermis. x360 (ep=epidermis).

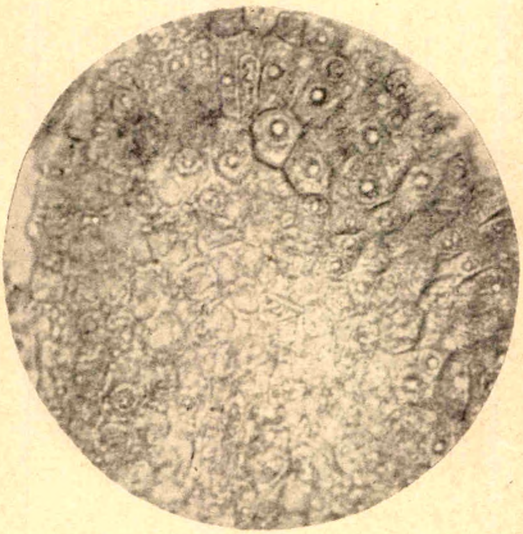


Fig. 10. t. s. of an anther showing a band of archesporial cells. x360.

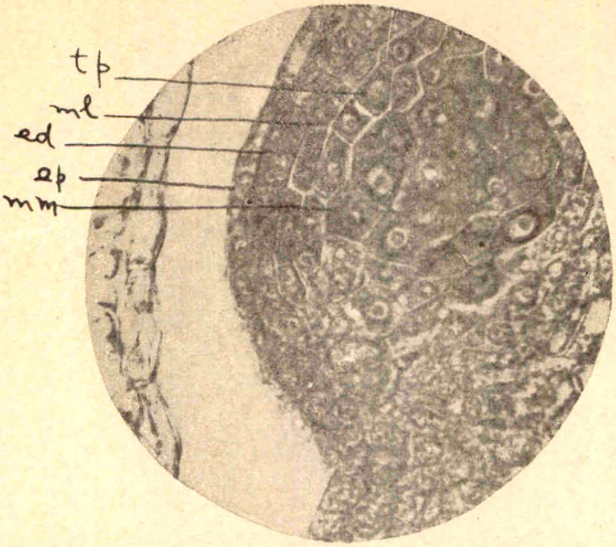


Fig. 11. Cross section of the anther lobe showing epidermis (ep.), endothecium (ed.). middie layer (m.l.) tapetum (tp.) and microspore mother cells (m.m). x625.

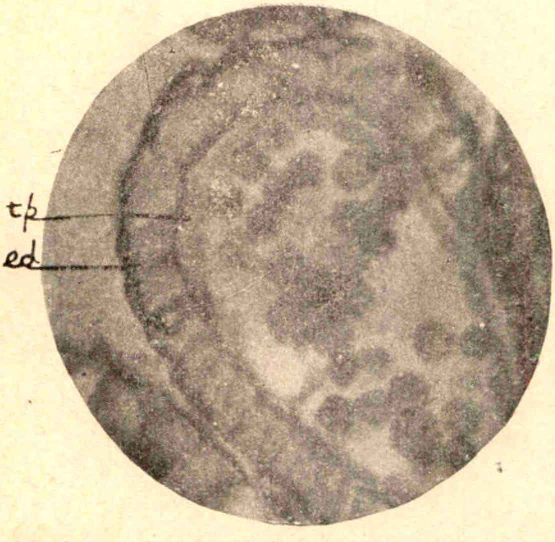


Fig. 12. t.s. of anther showing fibrous endothecium (ed.), degenerating tapetum (tp.) and microspores. x625.

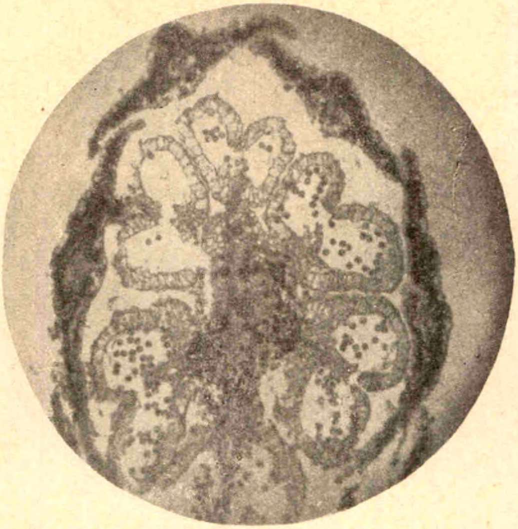


Fig. 13. t. s. of anther showing merging of locules. x65.

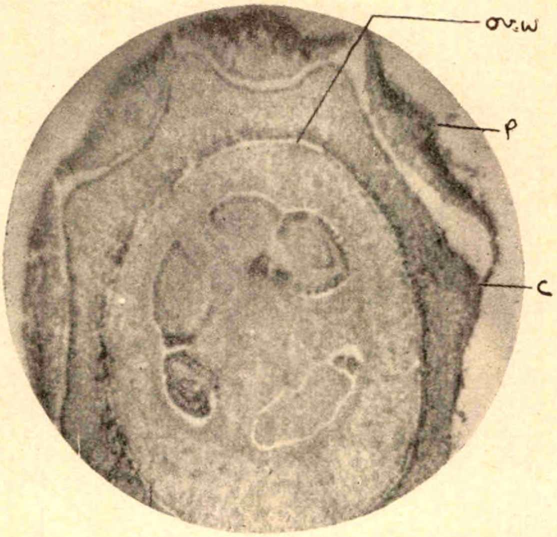


Fig. 14. t. s. of an ovary showing axile placentation, ridged cupule, parianth leaves and ovary wall. x35 (ovw.=ovary wall, C=cupule and p=perianth).

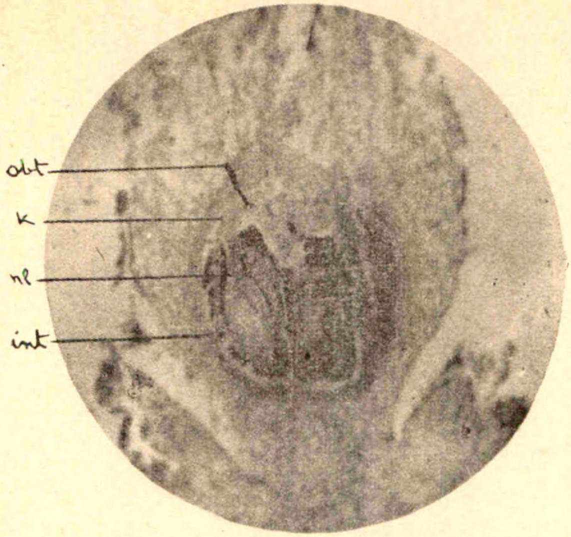


Fig. 15. l. s. of an ovary showing nucellus protruding outside the micropyle with a knobbed beak and establishing contract with obturator. x35 (obt=obturator, nl=nucellus, k=knobbed beak, int=integuments).

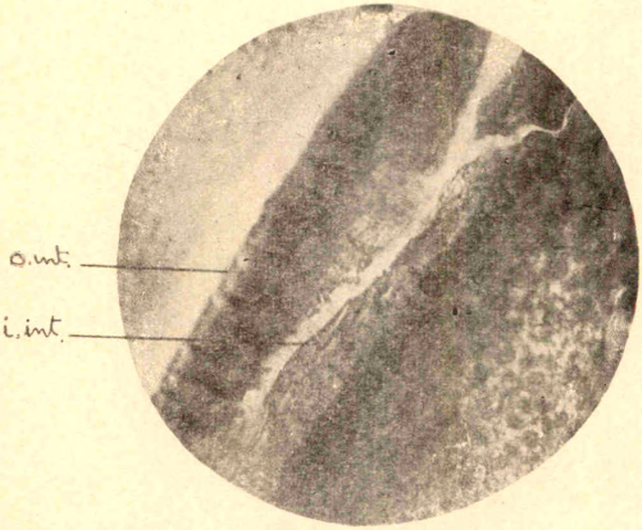


Fig. 16. l. s. of the ovule showing integuments, outer integument (o. int.) is two layered while inner integument (i. int.) is three layered. The inner cells of inner integument are filled with brown content. x715.

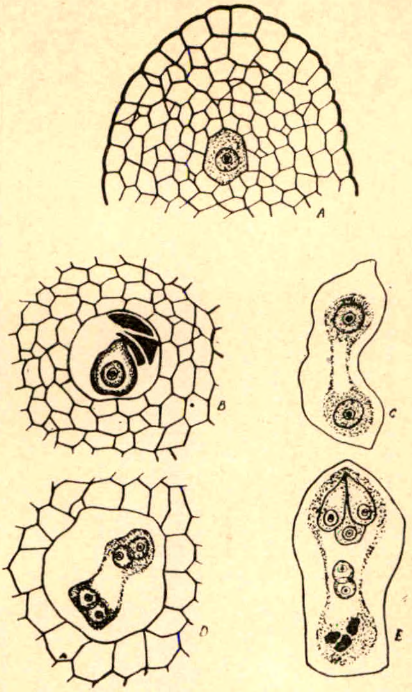


Fig. 17. A, megaspore mother cell lying at the centre of the embryo sac; B, three degenerated megaspores and the chalazal megaspore ready to divide; C, binucleate embryosac; D, tetranucleate embryo Sac; E, mature embryo sac with eggapparatus and two polar nuclei. A, B, C and D x660, E x600.

PHYSICO-CHEMICAL STUDIES ON COMPLEX CHROMIUM COMPOUNDS*

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"*Physico-chemical studies on complex Chromium compounds*" embodies the work of thiocyanates of tervalent chromium. Chromium (III) thiocyanates of metals Ag, Tl, Hg, Pb and Bi were studied for their compositions by thermometric and as well as conductometric titrations. Thermometric titrations were carried in aqueous as well as in aqueous-alcoholic medium between the metal solutions and potassium chromithiocyanate. In case of conductometric titrations Job's method of continued variation was applied and the measurements were made at constant controlled temperature. The results obtained were confirmative and comparable to those obtained by thermometric measurements. The points of inflection were obtained by plotting graphs. Conductometric titrations were also carried between organic tertiary bases and potassium chromithiocyanate. The compounds or (salts) were generally amorphous solids, insoluble in water and dil acids but soluble in certain organic solvents. The composition of these compounds was determined by analysis as well. These compounds were dissolved in particular organic solvents and the optical density was measured by changing the concentration. Effect of time on dissolution (specific rate) was also studied by spectrophotometer. The bases studied are dimethyl aniline, diethyl aniline, pyridine, α-picoline, β-picoline, γ-picoline, piperidine, 2, 6-lutidine and quinoline. Chromatographic study was also undertaken for separating Ag, Tl, Hg, Pb, Bi, Cu, and Cd and detection of these metals using potassium chromithiocyanate as developer.

The whole work has been divided into three chapters. Chapter I includes "Introduction" with general basic fundamentals and previous investigations carried by various workers. Methods of investigation *e.g.*, thermometric titrations, conductometric titrations, spectrophotometric study and paper chromatographic study have been included in first chapter. In the second chapter, record of investigations and discussions has been given under different parts. Part (I) includes thermometric study on the compositions of silver chromithiocyanate, thallous chromithiocyanate, mercuric chromithiocyanate, lead chromithiocyanate and bismuth chromithiocyanate. The discussion on the compositions of these *e.g.*, Ag, Tl, Hg, Pb and Bi chromithiocyanates has been given based upon both methods of titration (thermometric and conductometric) in the second part. Part (II) includes conductometric study on the compositions of silver chromithiocyanate, thallous chromithiocyanate, mercuric chromithiocyanate and lead chromithiocyanate and discussions on the results obtained along with bismuth chromithiocyanate. Apart from these chromithiocyanates, Part (II) also includes the chromithiocyanates obtained with dimethyl aniline, diethyl aniline, pyridine, α-picoline, β-picoline, γ-picoline, piperidine, 2,6-lutidine and quinoline. The discussion of all these chromithiocyanates has been given together on the basis of similar and comparable results. Part (III) includes spectrophotometric study on the decomposition in different solvents (alcohol and methyl-ethyl ketone) with time of potassium chromithiocyanate, dimethyl aniline chromithiocyanate, diethyl aniline chromithiocyanate, pyridine chromithiocyanate, γ-picoline chromithiocyanate, piperidine chromithiocyanate, 2,6-lutidine chromithiocyanate and quinoline chromithiocyanate. The discussion has been given separately of potassium chromithiocyanate (main), dimethyl- and diethyl-aniline chromithiocyanates, pyridine and γ-picoline chromithiocyanates, piperidine chromithiocyanate and quinoline chromithiocyanate.

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* Abstract of the thesis submitted to the Agra University for the degree of Doctor of Philosophy.

Part (IV) includes chromatographic study *e.g.*, separation of Ag, Tl, Hg, Pb,Bi, Cu and Cd by paper chromatography. Binary, ternary quaternary, pentanary mixtures were subjected to resolution. The detection was carried visually by using potassium chromithiocyanate solution. The chromatograms have been photographed in black-white, included in the thesis. Chapter (III) embodies the review in short of the whole work.

PHYSICO-CHEMICAL STUDIES ON THE INTERACTION OF TRANSITION METAL IONS WITH AMINO ACIDS AND RELATED SUBSTANCES

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The importance of metal chelates in most branches of chemistry and particularly in medicinal chemistry is now well recognized. Recent biological studies have shown, that organic compounds like glycine, cystein and ethylenediamine tetraacetic acid reduce radiation damage to exposed organisms by forming stable chelates with offending metal ions in the system. It has also been pointed out that the metal complexes which can by-pass normal proteins and release metal ions, that preferentially complex with sites on virus proteins, can prove effective in deactivating the offending protein molecules. The precise role of metal ions in such complicated systems has not been well understood. However an insight into this can be had firstly by studying the thermodynamic equilibria involved between metal ions and amino acids, the latter being the main constituents of proteins and secondly by investigating the nature of metal to donor bonds in these metal amino acid complexes. It was with this view that five amino acids (glycine, α-alanine, α-aminobutyric acid, β-alanine and β-aminobutyric acid) and four biologically important metal ions Cu(II), Ni (II), Co(II) and Zn(II) were chosen for the present investigation. A study has been made on the effect of (a) the structure of the ligand and (b) the physical properties of the metal ion, on the stability of these chelates. Thermodynamic functions $\triangle F$, $\triangle H$ and $\triangle S$ were determined to account for the actual and relative stabilities of metal chelates of amino acids and the nature of metal-donor bond has been investigated.

The interaction between the metal ions and amino acids was followed by measuring the changes in hydrogen ion activity in aqueous solutions containing the metal ion and the ligand. For accurate measurements of pH an electrometer null detector was fabricated incorporating Osram ET3 electrometer triode.

Metal complexes with low stability were studied by ion exchange method using carrier free radioactive isotopes.

The stability constants corresponding to the equilibria :

$$M + A \overset{k_1}{\rightleftharpoons} MA_1$$

$$M + A \overset{k_2}{\rightleftharpoons} MA_2$$

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(neglecting the hydration of the metal ion and the ligand) were calculated by Bjerrum's method. To evaluate thermodynamic functions, the formation constants were determined at 15°, 25° and 40° C. Dissociation constants of the ligands were determined under conditions identical with those maintained during complexometric studies.

On the basis of the data obtained in the present study, the relationship between the stability constants and the ionization potentials and electronegativities of the metal ions has been discussed. An analysis of the thermodynamic data showed that :

(1) both enthalpy (ΔH) and entropy (ΔS) changes favour the formation of metal amino acid complexes. The enthalpy term arises mainly from the interaction of amino nitrogen atom with metal ion while entropy changes are primarily due to the interaction of COO^- group with the metal ion.

(2) the ratio $\log k_1/k_2$ was always found to be positive. This was attributed to more favourable entropy change for the formation of first step complex species than for the formation of second step complex species.

(3) increase in the chain length of the ligand, in most of the cases, lowered the stability of its metal complexes. This was presumably due to unfavourable entropy change for the formation of metal complexes of ligands with higher molecular weight.

(4) the stability of metal chelates of amino acids is greatly decreased on enlarging the ring size of the chelate. This was attributed to the less favourable change in ΔS for the formation of metal complexes with larger ring size. However, there were indications that enthalpy term may also be unfavourable for the formation of larger ring metal chelates.

(6) there is a close relationship between the ligand basicity and stability of its metal complexes. All the systems studied in the present work showed this relationship.

(7) the entropy change for the formation of Ni(II), Co(II) and Zn(II) complexes of amino acids were found to be nearly equal. Higher values of ΔS for Cu(II) complexes of amino acids were explained on the basis of Jahn-Teller distortion.

The nature of metal to donor bonds in metal amino acid complexes was investigated by studying their infrared spectra in 3000 to 4000 cm^{-1} and 1600 cm^{-1} regions. Pd(II), Cu(II), Ni(II), Co(II) and Zn(II) complexes of amino acids were isolated in solid state and their molecular formula determined from microanalysis for carbon, hydrogen and nitrogen. Following conclusions were drawn from the relative changes in frequencies associated with amino and carboxylate groups :

(1) The sites of coordination in metal amino acid complexes are amino-nitrogen and oxygen of the carboxylate group.

(2) In the spectra of these complexes, N-H stretching frequency is considerably changed, while the frequency of antisymmetric carbon-oxygen stretching vibrations in the carboxylate ion, is not affected much. These observations have been explained by assuming a covalent bond between the nitrogen atom and the metal ion and an essentially electrostatic M-OCO bond.

(3) N-H of the first absorption band in the spectra of metal complexes of glycine, α-alanine and β-alanine and of the second absorption band in the complexes of aminobutyric acids followed the "Irving Williams" order of stabilities of metal chelates. In the case of metal complexes of β-alanine the relationship between $^{\nu}$N-H and log K was linear.

(4) The band due to antisymmetric carbon-oxygen stretching vibrations ($\simeq 1600\ \text{cm}^{-1}$) is not affected much on coordination of amino acid anion with the metal ions. However, the relative position of this band in the spectra of metal amino acid complexes depended on the nature of the metal ion. In most of the cases the order of $^{\nu}$C=O (antisymmetric) was:
$\text{Pd(II)} > \text{Cu(II)} > \text{Ni(II)} \simeq \text{Co(II)} \simeq \text{Zn(II)}$.

The visible absorption spectra of Ni(II) amino acid complexes were taken and the results were interpreted in the light of ligand field theory. It was observed that the frequency of experimentally observed absorption bands were in good agreement with the band positions predicted by Ballhausen's expressions for the octahedral complexes of d^8 systems. In view of this agreement an octahedral structure was assigned to Ni(II) complexes of amino acids.

TAXONOMY AND BIOLOGY OF INDIAN 'LEAF-MINING' INSECTS* (AGROMYZIDAE : CYCLORRHAPHA : DIPTERA)†

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The Agromyzidae, popularly known as "Leaf-miners", are minute to small and fragile flies, no larger than 3·0 mm and seldom reaching as much as 5·0 mm. in length. The members of this family during their larval stages attack various cultivated and wild plants where they make tunnels through the substance of the leaf, stem, pods and other parts of the plants. These phytophagous larvae during the course of their feeding on the leaf tissues leave behind a definite feeding pattern which might be compared to a "visiting card" on which the genus and sometimes species may be determined. Some of these "leaf-miners", because of their "leaf-mining" activities are of great agricultural importance. In the case of severe attack the whole foliage of the plant wilts. They show a special partiality to a large number of ornamental garden plants in addition to important crops like *Brassica campestris* L., *Pennisetum typhoideum* Rich., *Sorghum vulgaris* L., *Hordeum vulgaris* L. and *Cajanus indicus* L., where they cause havoc to the developing plants and seeds. Vegetables like *Solanum melongena* L., *Solanum tuberosum* L., *Lycopersicum esculentum* Mill. etc., are also not immune to them.

Inspite of the fact that these flies are so intimately associated with large number of economically important plants our knowledge of Indian forms has been practically nil up to this time. A perusal of the literature reveals in no uncertain terms the sad fact that Agromyzidae have failed to attract the attention of entomologists in this country. Therefore, the urgent need of taxonomic studies on the Indian Agromyzidae, on the basis of the modern concepts of classification was felt and the present work was undertaken.

The foregoing lines contain a detailed review of literature on the systematics of Agromyzidae and biological investigations especially from India; a detailed study on the biology and life-history of *Phytomyza atricornis* Meigen, a species which apart from attacking many garden plants cause a serious damage to the mustard crop; an outline of the more important external features of taxonomic importance, keys to the identification of various genera and species, descriptions and redescription of new and known species; and a catalogue of oriental species and host-plant index, besides a bibliography and figures.

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† An abstract of the thesis submitted and approved for the Ph.D. degree of the Agra University.

The observations on the biology of *Phytomyza atricornis* Meigen may be summarised as follows:—

The adults of *Phytomyza atricornis* Meigen are diurnal and positively heliotropic. These copulate between 8·00 a.m. to 5·00 p.m. and the copulation period lasts from half an hour to four hours. The pre-oviposition period ranges from three to six days. The fly deposits horizontally a single egg in a triangular puncture. The maximum number of eggs laid by a female is 746 at 20-28°C and 27-36% R.H. in 31 days. The rate of deposition of eggs stands highest in the second week and the lowest in the fifth week of oviposition. The egg-laying is comparatively more on the lower surface than the upper surface probably due to the availability of the shade and the presence of softer tissues like spongy parenchyma on the former. The eggs are mostly deposited in the margins of both the sides of the leaf rather than the middle of the blade. A female during its life span makes about 1118-2201 punctures. These punctures are of two categories *viz.*, (i) the pseudo punctures and (ii) egg-laying punctures. The former are feeding and the latter for deposition of eggs.

The egg is opalescent and ellipsoidal with a thin transparent chorion. The average viability of the egg is about 77%. The incubation period ranges from 2 days 1 hr. to 2 days and 20 hrs. at 20-25° C and 29-32% R.H. The larval period varies from 4·5-5·6 days with an average of 4·5 days in the laboratory, while it is 6-8 days with an average of 7·1 days in the field conditions.

The larval feeding results in the formation of the upper surface, the lower surface and full depth mines. The larval mines are of two types *viz.* (i) *linear* and (ii) *linear blotch.* The former is further divided into *Ophionome* and *heliconome* types. The larval mine varies from 7 to 10·1 cms. in length with an average of 8 cms. under the laboratory conditions.

The infestation on the periphery of the field is more pronounced than in the centre of the field. The leaves in the shade are preferred to those facing the bright sun-shine. The infestation of the mustard leaves is about 5% in the last week of January and 64% in the first week of March. The infested plants show retardation of growth.

The first instar larva has no spiracles. Its larval period varies from 24 hours and 30 minutes to 30 hours and 45 minutes with an average of 26·2 hours. The cephalopharyngeal skeleton of the first instar comprises an anterior mandibular hook and a large forked posterior part the paraclypeal phragma.

The second instar larva is amphipneustic, anterior spiracles with eight bulbs and the posterior with six bulbs. The larval duration of this instar ranges from 23 hours and 10 minutes to 32 hours and 10 minutes with an average of 26·7 hours.

The third instar is distinctly twelve segmented. Anterior spiracle having 10 bulbs and the posterior eight. The left mandible is about one and a quarter times the right mandible in the full grown maggot. An intermediate sclerite is an additional development in the cephalopharyngeal skeleton of the third stage larva. The duration of the third stage larva varies from 2 days and 18 hours to 3 days and 2 hours with an average of 2·86 days.

The full grown maggot pupates within the last larval skin. The average duration of prepupal stage varies from 3 hours and 45 minutes to 4 hours and 10 minutes with an average of 4 hours. The freshly formed pupa is yellowish and becomes dark-brown at the end of pupal period. The average duration of the pupa ranges from 7 days and 4½ hours to 11 days and 2 hours with an average of 8·8 days under laboratory conditions, while 11-14 days with an average of 12·4 days in the field. The pupae are parasitised by hymenopterous parasites.

The adult of *Phytomyza atricornis* emerges during 6·00 a.m. to 10·00 a.m. Some stray cases of emergence are, however, noticed in the after-noon hours. During emergence the adult breaks open the puparium and the epidermal surface of the mine enclosing the pupa. The highest percentage of emergence of adults from the pupae is attained during the second, third and fourth weeks of February with a temperature range varying between 20-27° C. The sex-ratio of the adults emerged is about 1 : 1 both from the field collected and the laboratory bred pupae. The maximum adult life of a female is 40 days average (35·3 days) and the male 34 days (average 27·1 days) at 20-32° C. and 27-36% R.H.

Dealing with the taxonomic studies, the salient features for the identification of the family Agromyzidae have been described. A detailed description of the morphological characters of a typical Agromyzid is given. A special attention has been paid to the characters of taxonomic importance for identification of genera and species. A key for the identification of the sub-families and genera is also provided. 21 species belonging to eight genera are dealt with; of these the following five are new to science:

(i) *Melanagromyza indica* sp. nov.
(ii) *Melanagromyza surdasi* sp. nov.
(iii) *Phytobia (Phytobia) ipeii* sp. nov.
(iv) *Phytagromyza keralaensis* sp. nov.
(*v*) *Phytagromyza agraensis* sp. nov.

Six species are recorded for the first time from within India.

(i) *Melanagromyza alternata* Spencer
(ii) *Melanagromyza atomella* (Malloch)
(iii) *Melanagromyza chalcosoma* Spencer
(iv) *Melanagromyza metallica* (Thomson)
(v) *Liriomyza subpusilla* (Malloch)
(vi) *Pseudonapomyza spicata* (Malloch)

Redescription, description and ecological notes of the eight inadequately described species is furnished. A taxonomic catalogue of the Oriental Agromyzidae containing 89 species has been prepared. A detailed host-plant index for the various species has been added.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr. T. Singh, Professor of Zoology and Entomology, School of Entomology, St. John's College, Agra for suggesting the problem, for facilities for work, for guidance and constant encouragement during the course of these investigations. My sincere thanks are also due to Dr. Santokh Singh for his help in various ways during the course of this work.

HYPERGEOMETRIC SERIES OF TWO & THREE VARIABLES*

Ramesh Chandra Pandey

Department of Mathematics, D.A.V. College, Kanpur.

In the first chapter I have given some recent developments in the field of hypergeometric functions of two and more variables. I have divided this chapter into three sections, namely

(1) Hypergeometric functions of two variables.
(2) Lauricella's hypergeometric functions of n variables.
(3) Saran's hypergeometric functions of three variables.

In the first section I have given Appell's and Horn's hypergeometric functions of two variables and their integral representations. I have also given the integral representation for F_1 given by Picard and also for F_2, F_3 and F_4, given by Erdélyi. I have also mentioned the relations between Appell's functions and Horn's functions given by Erdélyi.

In section two, I have given Lauricella's functions of n variables and their integral representations and also the functions of n variables given by Erdélyi and their integral representations.

In the third section I have given Saran's hypergeometric functions of three variables and integral representations for F_G, F_K, F_M, F_N, F_P, F_S, F_T with x, y as argument and for F_F and F_R with $x\,(1-z)$, y, $z\,(1-x)$ as argument. I have also given the integrals for these functions (Pochhammer' double loop type) and their transformations and differential equations satisfied by these functions as mentioned by Saran.

In the second chapter I have given the integral representations for F_E, F_F and F_R with x, y as argument which were not given by Saran. For example I have given the integral representation for F_E as

$$\frac{\Gamma(a_1)\Gamma(b_1)\Gamma(b_2)\Gamma(c_1-b_1)\Gamma(c_2-a_1)\Gamma(c_3-b_2)}{\Gamma(c_1)\Gamma(c_2)\Gamma(c_3)}F_E$$

$$=\int\int\int u^{a_1-1}\,v^{b_2-1}\,w^{b_1-1}(1-w)^{c_1-b_1-1}(1-v+uvy)^{c_3-b_2-1}\times$$

$$\times\,(1-u+uwx+uvz)^{c_2-a_1-1}du\,dv\,dw,$$

valid if $\mathrm{Rl}\,(c_1)>\mathrm{Rl}\,(b_1)>0$ and region of integration is a conicoid given by $u>0$, $v>0$, $0<w<1$, $1-v+uvy>0$ and $1-u+uwx+uvz>0$.

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I have also obtained the double integral representation for the function F_G. It differs from the integral given by Saran, for it elegantly gives the symmetry between the various parameters of the said function, which is as follows :

$$\frac{\Gamma(a_1)\Gamma(b_1)\Gamma(c_1-b_1)\Gamma(c_2-a_1)}{\Gamma(c_1)\Gamma(c_2)}F_G$$
$$=\int_0^1\int_0^1 u^{a_1-1}v^{b_1-1}(1-u)^{c_2-a_1-1}(1-v)^{c_1-b_1-1}(1-vx)^{b_2+b_3-a_1}\times$$
$$\times(1-vx-uy)^{-b_2}(1-vx-uz)^{-b_3}\,du\,dv,$$

valid if $\mathrm{Rl}(c_2)>\mathrm{Rl}(a_1)>0$ and $\mathrm{Rl}(c_1)>\mathrm{Rl}(b_1)>0$.

I have also given two transformations for the functions F_E and F_G.

In the third chapter I have obtained certain transformations of the hypergeometric functions of three variables, defined by Saran, by transforming the contour integrals representing the hypergeometric functions. I have divided this chapter in four sections. In the first section I have applied Euler's transformation, *viz.*,

$F(a, b; c; z)=(1-z)^{-a}\ F[a, c-b; c; z/(z-1)]$, and other transformations of F_1, F_2 and F_3 for transforming Saran's hypergeometric functions of three variables. For example we have proved that

$$F_E\,(a_1, a_1, a_1, b_1, b_2, b_2; c_1, c_2, c_3; x, y, z)$$
$$=(1-x)^{-a_1}F_E\,[a_1,a_1,a_1,c_1-b_1,b_2,b_2;c_1,c_2,c_3;x/(x-1),y/(1-x),z/(1-x)].$$

It may be noted that the relations of this type can be obtained if we can make a transformation in the functions involved in the integrand without effecting the parameters k and k' occuring in the functions.

In the second section linear transformations of Saran's hypergeometric functions of three variables have been discussed, when the parameters are connected by some relation. For example, we can express the function F_F in terms of a new function, *viz.*,

$$F_F\,(c_1+c_2-1, c_1+c_2-1, c_1+c_2-1, b_1, b_2, b_1 ; c_1, c_2, c_2 ; x, y, z)$$
$$=(1-x-z)^{-b_1}\ (1-y)^{-b_2}\times$$
$$\times\sum_{m,n,p=0}^{\infty}\frac{(b_1,m+p)(b_2,n)(1-c_1,n+p-m)(1-c_2,m-n-p)}{(1, m)(1, n)(1, p)}\times$$
$$\times[x/(1-x-z)]^{\mathrm{m}}\ [y/(1-y)]^{\mathrm{n}}\ [z/(1-x-z)]^{\mathrm{p}}.$$

In the third section I have obtained Quadratic transformations of the hypergeometric functions of three variables using the contour integrals. For example, we have proved

$$F_E\,(a_1, a_1, a_1, b_1, b_2, b_2; 2b_1, c_2, c_3; x, y, z)$$

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$$= \int\int\int u^{a_1-1}\, v^{b_2-1}\, w^{b_1-1}\, (1-w)^{c_1-b_1-1} (1-v+uvy)^{c_3-b_2-1} \times$$

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valid if Rl $(c_1) >$ Rl$(b_1) > 0$ and region of integration is a conicoid given by $u>0$, $v>0$, $0<w<1$, $1-v+uvy>0$ and $1-u+uwx+uvz>0$.

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$$\times(1-vx-uy)^{-b_2}(1-vx-uz)^{-b_3}\,du\,dv,$$

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$$=(1-x-z)^{-b_1}(1-y)^{-b_2}\times$$
$$\times\sum_{m,n,p=0}^{\infty}\frac{(b_1,m+p)(b_2,n)(1-c_1,n+p-m)(1-c_2,m-n-p)}{(1,m)(1,n)(1,p)}\times$$
$$\times[x/(1-x-z)]^m\,[y/(1-y)]^n\,[z/(1-x-z)]^p.$$

In the third section I have obtained Quadratic transformations of the hypergeometric functions of three variables using the contour integrals. For example, we have proved

$$F_E(a_1, a_1, a_1, b_1, b_2, b_2; 2b_1, c_2, c_3; x, y, z)$$

$$=(1-\tfrac{1}{2}x)^{-a_1}\sum_{m,n,p=0}^{\infty}\frac{(a_1,2m+n+p)(b_2,n+p)}{(1,m)(1,n)(1,p)(b_1+\frac{1}{2},m)(c_2,n)(c_3,p)}\times$$
$$\times[x^2/4(2-x)^2]^m\,[y/(1-\tfrac{1}{2}x)]^n\,[z/(1-\tfrac{1}{2}x)]^p,$$

by using the quadratic transformation of Gauss's series

$$F(a,b;2b;z)=(1-\tfrac{1}{2}z)^{-a}\,F[\tfrac{1}{2}a,\tfrac{1}{2}a+\tfrac{1}{2};b+\tfrac{1}{2};z^2/(2-z)^2].$$

In the fourth section I have given few interesting cases, when these functions reduce to other known functions by giving particular values to the parameters or by putting the variables equal. For example, I have proved that

$$F_K(a_1,a_2,a_2,b_1,b_2,b_1;c_1,b_2,c_3;x,y,z)$$
$$=(1-y)^{-a_2}\,F_2[b_1,a_1,a_2;c_1,c_3;x,z/(1-y)],$$

and

$$F_G(a_1,a_1,a_1,b_1,b_2,b_3;c_1,c_2,c_2;x,y,y)$$
$$=(1-x)^{-a_1}\,F_2[a_1,c_1-b_1,b_2+b_3;c_1,c_2;x/(x-1),y/(1-x)].$$

In the fourth chapter I have obtained the sums of various hypergeometric functions of two and three variables at different points.

I have divided this chapter in five sections. In the first section I have given the sums of Appell's functions F_1, F_2 and F_3, at different points. For example

$$F_1(a,b,b';\tfrac{1}{2}+\tfrac{1}{2}a+\tfrac{1}{2}b+b';\tfrac{1}{2},1)$$
$$=\frac{\Gamma(\frac{1}{2})\Gamma(\frac{1}{2}+\frac{1}{2}a+\frac{1}{2}b+b')\,\Gamma(\frac{1}{2}-\frac{1}{2}a+\frac{1}{2}b)}{\Gamma(\frac{1}{2}+\frac{1}{2}a)\,\Gamma(\frac{1}{2}+\frac{1}{2}b)\,\Gamma(\frac{1}{2}-\frac{1}{2}a+\frac{1}{2}b+b')}.$$

In the second section I have given the sums of F_G, F_M and F_S functions at different points, *e.g.*,

$$F_G(a_1,a_1,a_1,b_1,b_2,b_3;1+a_1+b_1-b_2-b_3,c_2,c_2;1,1,1)$$
$$=\frac{\Gamma(c_2)\Gamma(1-b_2-b_3)\,\Gamma(c_2+b_1-a_1-b_2-b_3)\,\Gamma(1+a_1+b_1-b_2-b_3)}{\Gamma(c_2-a_1)\,\Gamma(1+b_1-b_2-b_3)\,\Gamma(1+a_1-b_2-b_3)\,\Gamma(c_2+b_1-b_2-b_3)}.$$

In the third section I have obtained the sums of the function F_N, at the point $x=y=z=1$, under different restrictions. For example,

$$F_N(a_1,a_2,a_3,b_1,b_2,b_1;1+a_1+b_1-a_3,1+a_2+b_2,1+a_2+b_2;1,1,1)\;.$$
$$=\frac{\Gamma(1-a_3)\Gamma(b_1-b_2)\Gamma(b_1-a_2)\Gamma(1+a_2+b_2)\Gamma(1+a_1+b_1-a_3)}{\Gamma(b_1)\Gamma(b_1-a_2-b_2)\Gamma(1+b_1-a_3)\Gamma(1+a_2+b_2-b_1)\Gamma(1+a_1+b_2-a_3)}\times$$
$$\times\frac{\Gamma(1+a_1+a_2+b_2-a_3-b_1)}{\Gamma(1+a_1+a_2-a_3)}.$$

In the fourth section I have tried to find out the sums of the function F_T when the argument is the combination of $\frac{1}{2}$, 1 and -1. These sums have been obtained with $z=1$ and x and y are either 1 or $\frac{1}{2}$ or -1. For example

$$F_T\,(a_1, a_2, a_2, b_1, b_2, b_1\ ;\ c_1, c_1, c_1\ ;\ x, y, z)$$

$$=\frac{\Gamma(c_1)\ \Gamma(c_1-a_1-a_2-b_1)\ \Gamma(c_1-a_2-b_1-b_2)}{\Gamma(c_1-a_1-a_2)\ \Gamma(c_1-a_2-b_1)\ \Gamma(c_1-b_1-b_2)}.$$

In the fifth section I have obtained the sum of the function F_F, with $(-4,\ 1,\ 1)$ as argument, under different restrictions.

In the fifth chapter I have tried to find out the expansions of Saran's hypergeometric functions of three variables, similar to those of J. L. Burchnall and T. W. Chaundy, by using the inverse pair of symbolic operators

$$\nabla(h)=\frac{\Gamma(h)\ \Gamma(\delta+\delta'+h)}{\Gamma(\delta+h)\ \Gamma(\delta'+h)},$$

and

$$\Delta(h)=\frac{\Gamma(\delta+h)\ \Gamma(\delta'+h)}{\Gamma(h)\ \Gamma(\delta+\delta'+h)},$$

where δ and δ' stand for $x\ \partial/\partial x$ and $y\ \partial/\partial y$ respectively. The operator $\nabla(h)$ changes $(h, m)(h, n)x^m y^n$ into $(h, m+n)x^m y^n$, so, if $(h, m)(h, n)$ occurs in the numerator of the coefficient of $x^m y^n$, it is changed into $(h, m+n)$ by the operator $\nabla(h)$. The operator $\Delta(h)$ effects a similar change in the denominator. We have thus obtained a number of expansions. For example, we have proved that

$$F_K\,(a_1, a_2, a_2, b_1, b_2, b_1\ ;\ c_1, c_2, c_3\ ;\ x, y, z)$$

$$=\sum_{r=0}^{\infty}\frac{(a_1, r)(a_2, r)(b_1, r)}{(1, r)(c_1, r)(c_3, r)}\ x^r z^r F(a_1+r, b_1+r\ ;\ c_1+r\ ;\ x)\times$$

$$\times F_2(a_2+r, b_2, b_1+r\ ;\ c_2, c_3+r\ ; y, z)$$

and

$$F(a_1, b_1\ ;\ c_1\ ;\ x)\ F_2(a_2, b_2, b_1\ ;\ c_2, c_3\ ; y, z)$$

$$=\sum_{r=0}^{\infty}(-)^r\ \frac{(a_1, r)(a_2, r)(b_1, r)}{(1, r)(c_1, r)(c_3, r)}\ x^r z^r\times$$

$$\times F_K\,(a_1+r, a_2+r, a_2+r, b_1+r, b_2, b_1+r\ ;\ c_1+r, c_2, c_3+r;\ x, y, z).$$

To justify the proofs of our expansions we have proved the conditions of absolute convergence for these expansions. For this we take all the parameters real and positive and replace each term by its absolute value. Further, we have found out the bounds for the hypergeometric functions with positive variables when their positive parameters diverge to infinity in certain ways. We have established these bounds by first proving the simple inequalities which have been given in the form of lemmas. Thus using these asymptotic forms in our expansions, we have also found out the regions of convergence.

In the sixth chapter I have given hypergeometric functions of two variables with extended parameters and their integral representations for these functions leaving aside 3rd, 8th and 9th type functions, representations for which have been already given by Kampe De Feriet. We have also generalised these integrals to higher parameters, similar to the integrals given by Kampe De Feriet. I have also given Pochhammer's double loop type integrals for all the ten functions.

For example, I give here one function out of ten functions and its simple integral representation and also Pochhammer's double loop type integral representation.

$$F\left(\begin{array}{c|l|l} 2 & a_1 \qquad ; a_2 & \\ 1 & b_1,\ b'_1 & \\ 1 & c_1 & x, y \\ 1 & d_1,\ d'_1 & \end{array}\right) = \sum_{m,n=0}^{\infty} \frac{(a_1, m+n)(a_2, m+n)(b_1, m)(b'_1, n)}{(1,m)(1,n)(c_1, m+n)(d_1, m)(d'_1, n)} x^m y^n$$

$$r+s=1$$

$$\cdot\ \frac{\Gamma(a_2)\ \Gamma(b_1)\ \Gamma(b'_1)\ \Gamma(c_1-a_2)\ \Gamma(d_1-b_1)\ \Gamma(d'_1-b'_1)}{\Gamma(c_1)\ \Gamma(d_1)\ \Gamma(d'_1)} F\left(\begin{array}{c|l|l} 2 & a_1 \qquad ; a_2 & \\ 1 & b_1,\ b'_1 & \\ 1 & c_1 & x, y \\ 1 & d_1,\ d'_1 & \end{array}\right)$$

$$= \int_0^1 \int_0^1 \int_0^1 u^{a_2-1}\ v^{b_1-1}\ w^{b'_1-1}\ (1-u)^{c_1-a_2-1} (1-v)^{d_1-b_1-1} \times$$

$$\times (1-w)^{d'_1-b'_1-1}\ (1-uvx-uwy)^{-a_1}\ du\ dv\ dw,$$

provided $Rl(c_1) > Rl(a_2) > 0$, $Rl(d_1) > Rl(b_1) > 0$ and $Rl(d'_1) > Rl(b'_1) > 0$.

$$F\left(\begin{array}{c|l|l} 2 & a_1 \qquad ; d_1+d'_1-1 & \\ 1 & b_1,\ b'_1 & \\ 1 & c_1 & x, y \\ 1 & d_1,\ d'_1 & \end{array}\right) = \frac{\Gamma(d_1)\ \Gamma(d_1')\Gamma(2-d_1-d'_1)}{(2\pi i)^2} \times$$

$$\times \int_C (-t)^{-d_1} (t-1)^{-d'_1} F_1[a_1, b_1, b'_1\ ;\ c_1\ ; x/t, y/(1-t)]\ dt,$$

where $|t| > |x|$ and $|1-t| > |y|$ along the contour C.

In the seventh chapter, I have given the various transformations of the functions defined in the sixth chapter at the point $x=y=1$. Some of the transformations have given very interesting results in Appell's hypergeometric functions and in some cases, I have been able to get the sums also. For example, we have proved that

$$F\left(\begin{array}{c|l|l} 1 & a_1 & \\ 2 & b_1,\ b'_1\ ;\ -m,\ -n & 1, 1 \\ 1 & c_1 & \\ 1 & c_1,\ d'_1 & \end{array}\right)$$

$$= \frac{(c_1-a_1,\ m+n)}{(c_1,\ m+n)} F\left(\begin{array}{c|l|l} 1 & a_1 & \\ 2 & d_1-b_1,\ d'_1-b'_1\ ;\ -m,\ -n & 1, 1 \\ 1 & 1+a_1-c_1-m-n & \\ 1 & d_1,\ d'_1 & \end{array}\right)$$

and

$$F\left(\begin{array}{c|l|l} 1 & a_1 & \\ 2 & b_1,\ b'_1\ ;\ -m, -n & 1, 1 \\ 1 & c_1 & \\ 1 & 1+a_1+b_1-c_1-m,\ 1+a_1+b'_1-c_1-n & \end{array}\right)$$

$$= \frac{(c_1-a_1,\ m+n)(c_1-b_1,\ m)(c_1-b'_1,\ n)}{(c_1,\ m+n)(c_1-a_1-b_1,\ m)(c_1-a_1-b'_1,\ n)},$$

where $c_1 = b_1 + b'_1$.

ON SOME HELMINTHS OF WILD CAT—(*FELIS CHAUS*)*

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Lungs and liver from five specimens of *Felis chaus*, autopsied in the department, were available for collection of helminths and an assessment of the associated lesions. Among the nematode parasites of lungs in Felidae, the genus *Metathelazia* Skinker, 1931 (Syn. *Osleroides* Orlov, Davtian *et* Lubimov, 1933; *Vogeloides* Orlov, Davtian *et* Lubimov, in Skrjabin, 1933; *Papillosclerus* Khera, 1956) occurring in the bronchioles and the parenchyma, is known to be represented by the species—*M. felis* (Vogel, 1928), Syn. *Oslerus f* (v), *Osleroides* (*Osleroides*) *f* (v), *Vogeloides f* (v) Davtian, 1933, in *Felis pardalis* (South America); *M. massinoi* (Davtian, 1938), Dougherty, 1943, Syn. *Osleroides massinoi* (Davt.,), in *Felis catus* (Russia); *M. servalis* Chabaud *et* Biocca, 1950 in *Felis serval* (Somaliland) and *M. ramanujachari* (Alwar *et al*, 1958) in *Felis catus*. Of these, the specimens of *M. ramanujachari*, described from Madras (South India), did not exhibit any gross pathological lesions.

During an examination of the lungs, lung worms were collected on three occasions. A female specimen of *Spirocerca lupi* (Rud., 1809), Chitwood, 1930 was also recovered from one of the lungs. Pieces of lungs were preserved for subsequent histological study. The worms, on comparison with the known forms, exhibited certain morphological differences which necessitated their separation into a new species, designated herein as *Metathelazia cameroni*, which has been differentiated from the forms so far known from other carnivores. Besides, the sectioned material revealed adult specimens inside the bronchioles and in the adjacent parenchyma. The pathological changes, at such sites, are also described.

Metathelazia cameroni, n.sp.

The specimens, with characteristic 'teguminal sheath' round body and six lip-like structures around mouth opening, small in size but with comparatively thick body wall. Male (one specimen only available) 5·96 in length and 0·24 in breadth; with its nerve ring at 0·108 distance behind mouth opening; oesophagus 0·5 long; tail coiled, 0·06 in length; caudal papillae consisting of two pairs of pre-anals, a median pre-anal, a pair of adanals and three pairs of postanals; spicules nearly equal, bent in form, 0·26—0·3 in size, with alate inner margins, hooked proximally but somewhat blunt distally; gubernaculum boat-shaped, in two pieces, 0·032×0·004 in size (Figs. 1 and 2). Females 14·03 in length and 0·52 in breadth; with oesophagus 0·54 in length; nerve ring at 0·14 distance behind anterior end; anus lying at 0·08 distance in front of posterior extremity; vulva at 0·172 distance from posterior extremity-distance between anus and vulva equal to the distance between anus and posterior extremity *i.e.*, 0·088; intravaginal eggs fully formed, embryonated, thick-shelled, 0·040 × 0·028 in size; first stage larvae from decant from lungs and faecal mass with characteristic feature of the tip of tail and 0·28 and 0·30 in size respectively (Figs. 3 to 6).

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* Part of the Thesis approved for the award of M.V.Sc. degree of Agra University (1963) to S.C.S. under supervision of B.P.P.

Gerichter (1948), in a study of this genus, gave a useful key for differentiating the valid species known till then. Its various forms have been listed by Yamaguti (1961). Chabaud (1963) has provided criteria for distinguishing the forms that have been assigned to this genus.

The present material, on the character of the caudal papillae in male, is quite distinct from all the forms so far described from Felidae. It differs from *M. ramanujachari* on account of its smaller size and on the number and distribution of the caudal papillae which in the latter are described as indistinct, consisting of two pairs of preanals and two pairs of postanals though in matter of the size of the females, their eggs and the relative position of anus and vulva our material agrees with *M. ramanujachari.* Amongst the other forms from carnivores and likewise having the distance vulva-anus tip of tail, *M. felis* can be distinguished by possession of three pairs of preanal and four pairs of postanal papillae; *M. massinoi* has three pairs of preanals and five pairs of postanals; *M. servalis* is with three pairs of preanals, two pairs of adanals and five pairs of postanal papillae and in *M. chabaudi* Singh and Pande (1963), from mongoose, the caudal papillae consist of one pair of preanals, one pair of adanals and three pairs of postanals. *M. californica* Skinker, 1931; *M. ascaroides* (V. Linstow, 1879) Dougherty, 1943; *M. capsulata* Gerichter, 1948; *M. multipapillosa* Gerichter, 1948; *M. exilis* Biocca *et* Chabaud, 1952, have also an entirely different arrangement of the total number of paired papillae.

The type specimens deposited in the Departmental collection.

Host-parasite relationship

Histopathological study of the lung tissue, harbouring worms, revealed males and females inside alveolar parenchyma, bronchi and bronchiolar walls but the latter appeared to be the favoured site for abode of adults (Fig. 7). An extensive damage to the bronchiolar mucosa and alveolar parenchyma was accompanied, in both cases, with a heavy infiltration with leucocytes, lymphocytes and macrophages. In consequence of irritation caused by worms, fibrino-mucous exudate had resulted in the bronchiolar spaces which also exhibited erythrocytes and large number of leucocytes around sections of worms (Fig. 8). From an excessive accumulation of such exudate, occlusion and consolidation had resulted at affected sites. The adult worms appeared to feel mostly on such exudates which also showed developing eggs and larvae.

Liver

Liver, on incision, yielded a large number of liverflukes which belonged to *Opisthorchis caninus* (Lewis *et* Cuninghum, 1872) Barker, 1911 (Syn. *Paro-*

pisthorchis caninus Stephens, 1912) which, during the earlier surveys, had been found to be the common liverfluke of Indian domestic carnivores, dog and cat (Gupta, 1961).

Grossly, the liver did not exhibit any lesion but, many flukes, cut in various planes, were seen lying packed up inside the bile ducts. A great destruction of the biliary epithelium, from activity of its suckers, had resulted (Fig. 9). Presence of blood in the intestines indicated that it fed also on blood. The biliary epithelial cells were denuded and the degenerated cells, in the lumen of ducts, occurred in a necrosed mass. Around the degenerated epithelium, an infiltration with leucocytes, lymphocytes and macrophages was evident. A proliferation of fibrous tissue of the duct which was infiltrated with lymphocytes and macrophages had resulted in its thickening which was the most prominent of all the changes noticed (Fig. 10).

SUMMARY

Felis chaus, was found to harbour a lungworm and a liverfluke, the former has been studied and assigned to a new species, *Metathelazia cameroni*, and the latter indentified as *O. caninus*. The attendant pathological changes, at sites of their occurrence, have been described from sectioned material. The report, a first record from this wild feline host, also includes finding of a female specimen of *Spirocerca lupi* in one of the lungs.

ACKNOWLEDGEMENT

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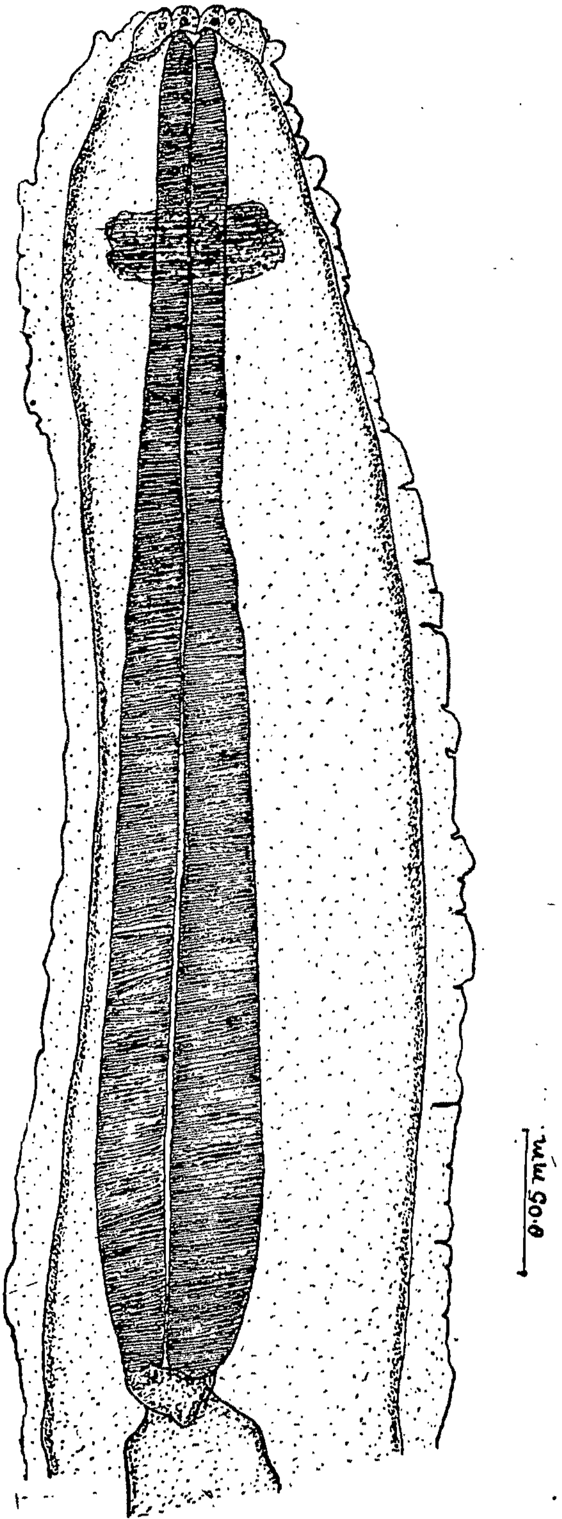
(All measurements in mm.)



M. cameroni : (Camera lucida drawings, Figs. 1 to 6).
Fig. 1. Anterior end, showing teguminal sheath and the lips.

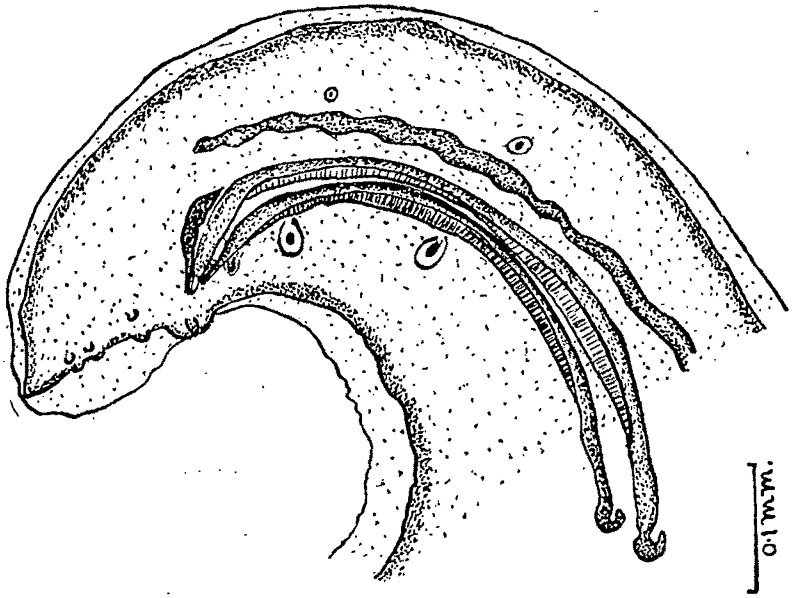


Fig. 2. Posterior end of male showing arrangement of papillae and bent alate spicule with boat-shaped gubernaculum.

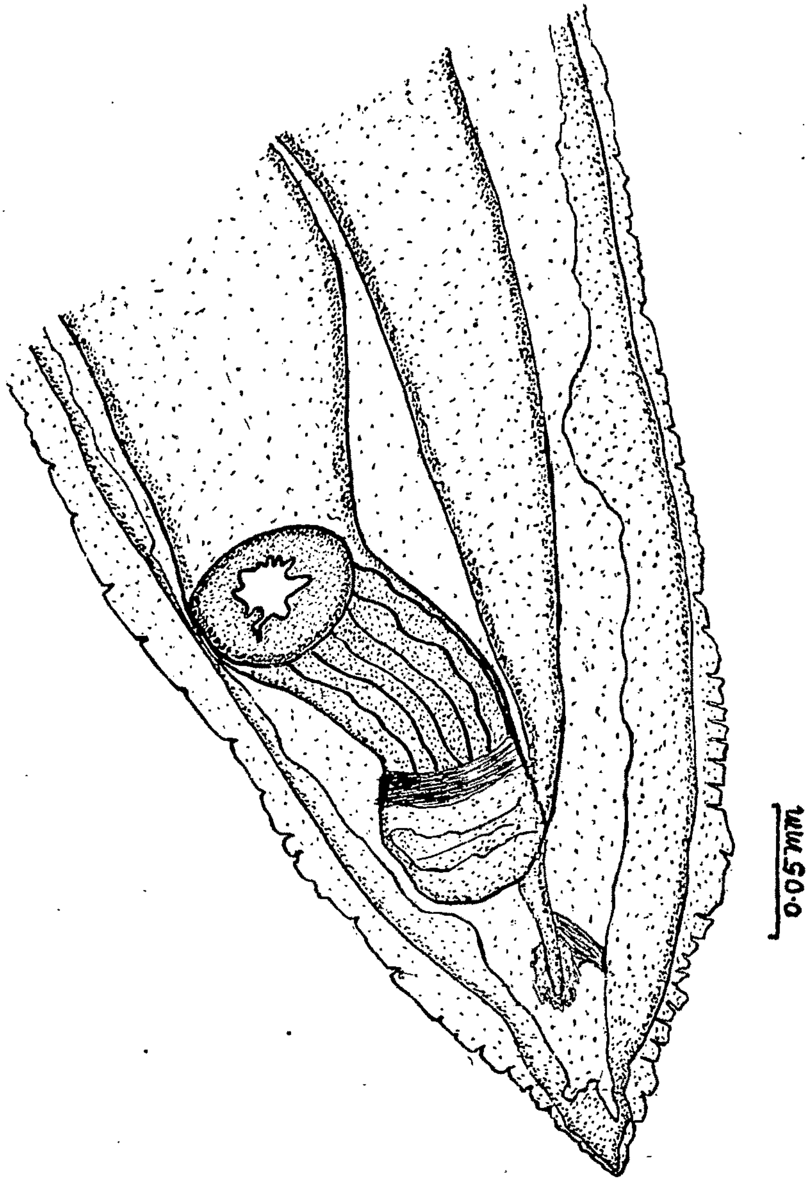


Fig. 3. Posterior end of female (dorsal view) showing vua, vagianvlanad nus.

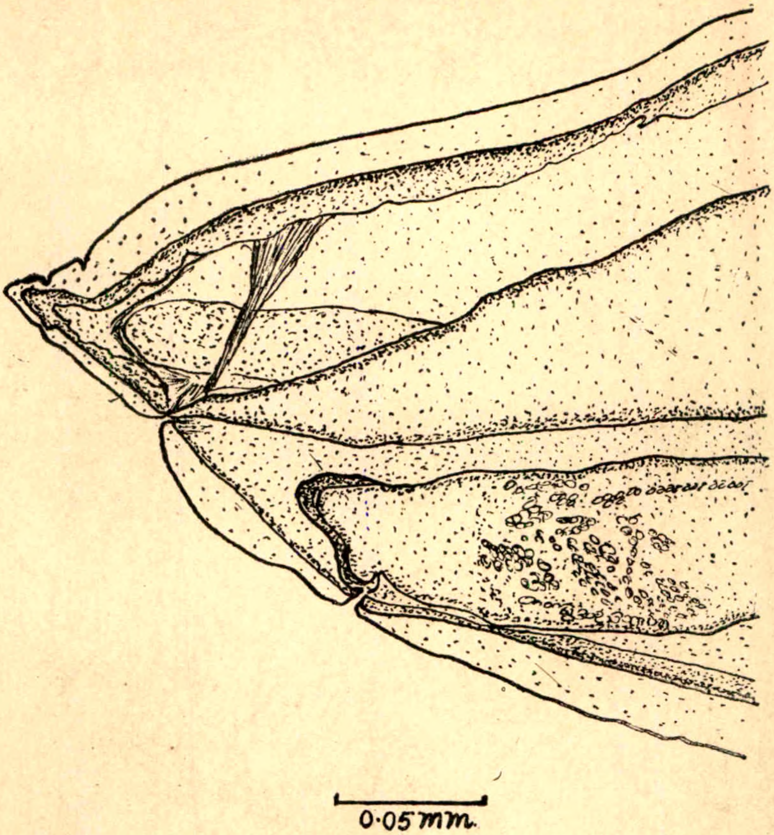
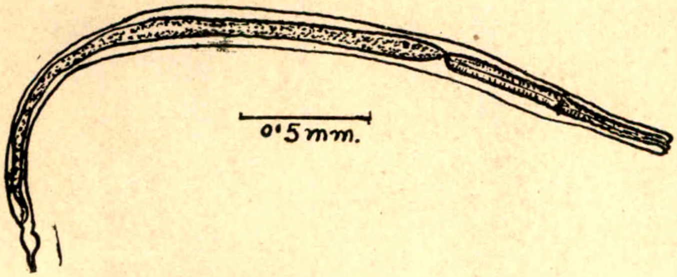


Fig. 4. Posterior end of female (lateral view) showing situation of vulva and anus from the tip.



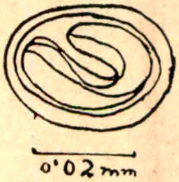
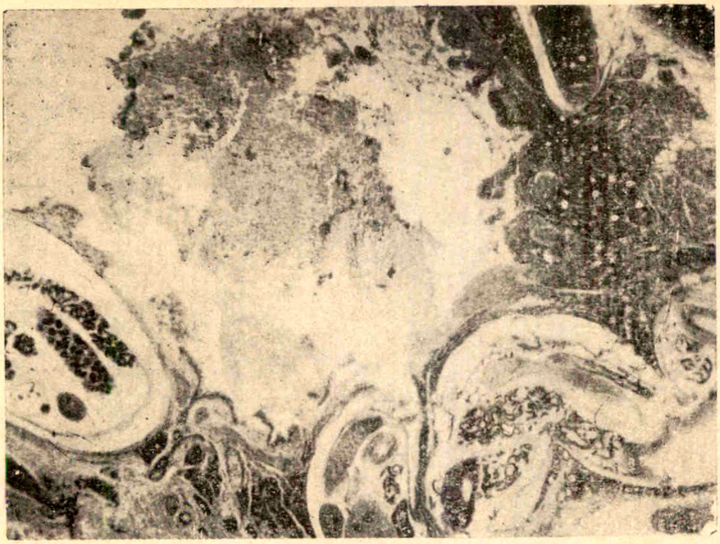


Fig. 5. Larva (entire), collected from faeces.
Fig. 6. Egg.



(Photomicrographs, Figs. 7 and 8).

Fig. 7. Portion of a section of lung showing a gravid female with damage to wall of bronchiole with exudate in the centre. (x 48).

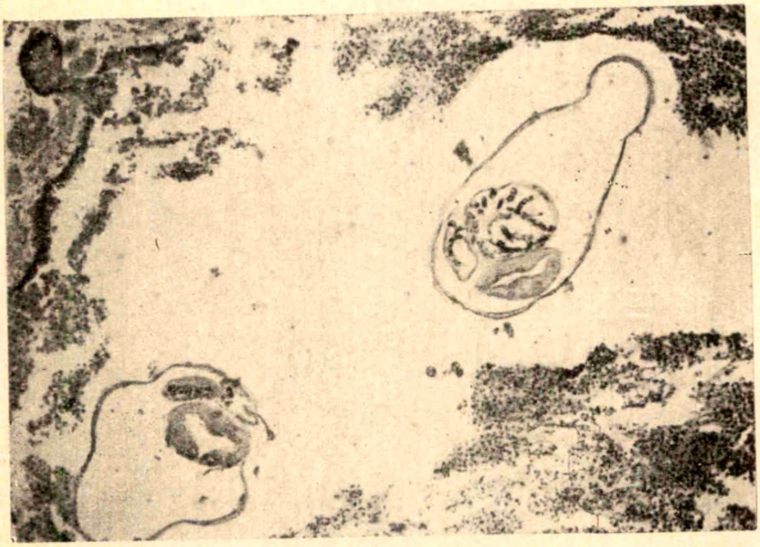
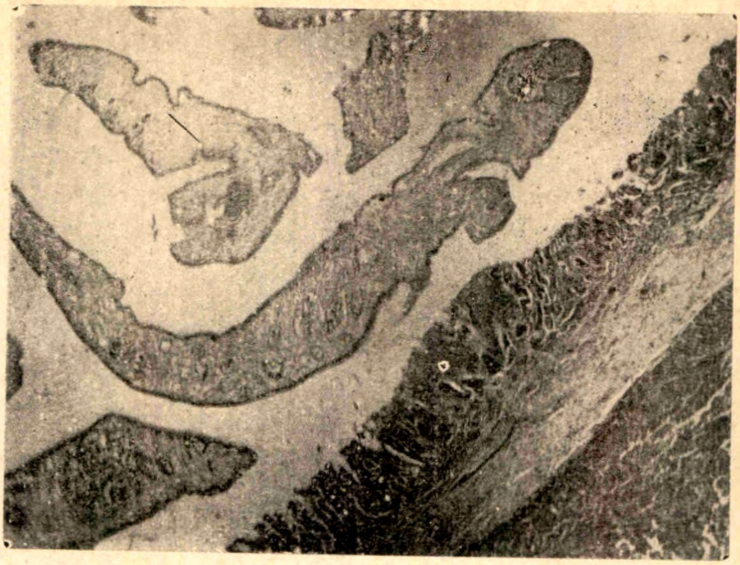


Fig. 8. Portion of another section of lung with lumen of bronchiole having exudate and two worms cut in it (x 48).



O. caninus : (Photomicrographs, Figs. 9 and 10).

Fig. 9. Portion of a section of liver showing bile duct with specimens cut in various planes. (x 48).

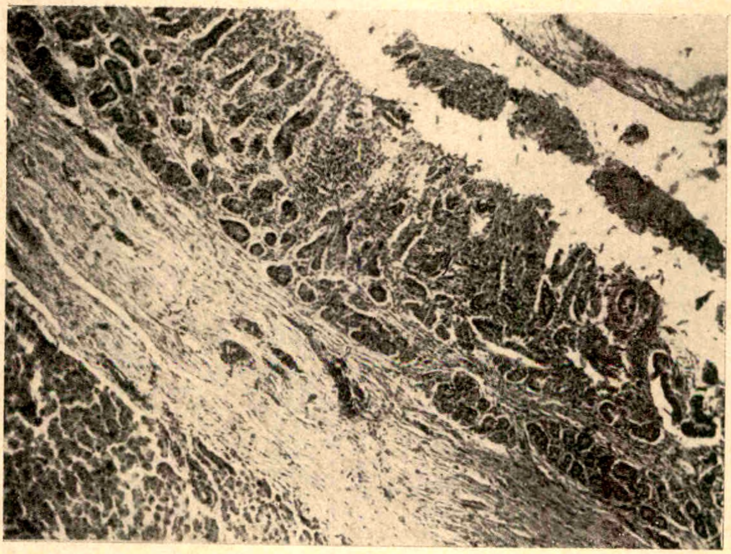


Fig. 10. Tissue changes in the wall of bile duct. (x 90).

ELECTRODE PROCESSES WITH SPECIAL REFERENCE TO ELECTRODE REACTIONS AND THEIR KINETICS

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The importance of kinetics and mechanism of electrode processes is due not only to the fact that it enables us to understand the basis of most of technological electrochemistry but also because it represents a branch of reaction kinetics in which the effect of controlled changes in the energy of activation can be accurately observed. The problem may be investigated by studying the behaviour of electrodes on passing an alternating current through them, or by the transient techniques. The kinetic parameters of the rapid electrode reactions are generally deduced by relaxation methods by following the potential step (potentiostatic method) or the current step (galvanostatic method) or electrolysis with superimposed alternating voltage, which have been developed during the last decade and form a significant advance in electro-chemical kinetics.[1]

The thesis incorporates some interesting results obtained in the study of kinetics of a few electrode processes using four newly developed techniques :

(1) A. C. Polarography : study of reduction processes at the dropping mercury electrode in pulsating fields.
(2) Faradaic effects of alternating and direct currents.
(3) Depolarization kinetics study in an open circuit.
(4) Study of kinetic parameters of reactions at platinum/electrolyte interfaces by the faradaic rectification method—Redoxokinetic effect

The results obtained are summarised below :

(1) *A. C. Polarography :*

The technique for measurement of a.c. components of the pulsating current in a.c. polarographic measurements introduced by Breyer and Gutman and adopted by Doss and Kalyanasundaram was modified in two ways[2] and employed for the study of the reduction of zinc, copper and chromium ions. Firstly, the measurements were made in the region where the amplification of the two stage 1 L D 5 amplifier is linear at a particular frequency of alternating current. Secondly, the external resistance in dropping mercury electrode circuit was kept constant throughout. Further, the pulsating fields were not limited to 50 cycles/sec., as done by Breyer and Gutman but covered a wide range of frequency. That a dropping mercury electrode behaves like a combination of a capacitative and resistive impedance is convincingly confirmed[2,3] by the results obtained at different frequencies. The magnitude of the external resistance used in the dropping electrode circuit has a marked effect on a.c. maximum.

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* Abstract of the thesis submitted to Agra University for the degree of Doctor of Science.

In the case of discharge of copper ions, the a.c. maximum appears at a frequency of 1000 cyles/sec., using an external resistance of 200 ohms in the dropping electrode circuit. With the increase in the pH of the media, the half wave potentials are markedly influenced; at pH beyond 7 the wave splits up into a doublet due to copper citrate complexes.

The rates of discharge of copper and chromium ions show that the reduction of copper ions is fastest and the reduction of chromous ion to chromium is faster than the reduction of chromic ion into chromous ion.

(2) *Faradaic effects of alternating and direct currents :*

(a) The electrolysis of potassium iodide in an alternating field at varying frequencies shows quantitatively that the current efficiency increases with the rise in temperature, lowering of frequency, decrease in duration for electrolysis and the increase in current density[4]; and the square of current efficiency generally varies with current density. These results can be explained on the basis of theory of absolute reaction rates.

(b) Using a direct current, 4 : 6 dinitro-o-cresol and 5-nitro-barbutaric acid have been electrolytically converted into 4 : 6 diamino-o-cresol sulphate and uramil, respectively. Acrylic acid in concentration of 7% in 10% sulphuric acid polymerises on electrolysis at 22°—23°C; if its concentration is reduced to one-fifth, the product formed is propionic acid. Similarly, mandelic acid and benzillic acid on electrolytic reduction give phenyl acetic acid and diphenyl acetic acid respectively.

(c) Emulsions have been prepared, using a direct current at the organic liquid-aqueous interface. An interesting feature observed[5] is that no emulsion is formed on passing the electric current through the electrodes dipped in the aqueous phase separated by the nitrobenzene phase (using a U-tube), but on switching off the current, water-in-oil type of emulsion is obtained.

(3) *Depolarization Kinetics :*

When a cathodically polarised platinised platinum electrode is allowed to depolarize in open circuit or when a small anodic current is allowed to be drawn through the polarized electrode, two inflexions are obtained in the depolarization potential time curve, especially when the electrodes are polarized above the decomposition potential.[6,7] The results are extraordinarily reproducible and the occurrence of inflexions is significant (i) in assessing the surface activity of simple molecules, macro molecules,[8] pH indicators or of surfactants,[9] (ii) in determining the effects of electrode material[10] and non-aqueous liquids[11] (iii) in finding out the efficiency and the concentration of oxidants[12] used as depolarising agents, (iv) in determining the thickness of gold[13] and platinum coating,[14] without either etching the surface or cutting any section out of it, and (v) in detecting imperfections in the deposits[13] and thereby helping in getting rust proof coatings.

(4) *Redoxokinetic effect—Faradaic rectification :*

The rectification of alternating current by electrodes dipped in an aqueous solution containing a reversible redox couple was at one time called as 'Redoxokinetic effect'[15] but is now commonly known as Faradaic rectification.[16] During the past three years more than two dozen good publications have appeared from India and abroad. This effect is widely applicable in Analytical Chemistry. Based on this effect Doss and co-workers[17] have developed a new technique of estimation known as Redoxokinetic titration or Impedance titration; Barker[18] has developed RF Polarography which enables the determination of concentration of a metal ion as low as 10^{-10} gm. in 0·01 c.c. of a solution, and for the first time the measurement of rate constants and transfer coefficients of very rapid metal ion-amalgam electrode reactions has become possible.[18,19]

To avoid the effect of impurities at the metal (solid)-solution interface, the kinetic parameters have generally been measured using dropping mercury electrode with the consequent neglect of theoretical knowledge of the role of inert metal in determining the mechanism of the process. For platinum-solution interfaces, the values of transfer coefficient were reported[20] to be tentative and illustrative of the procedure. Narayanan and coworkers[21] measured them after specially treating the electrode surface, and observed that the redoxokinetic potential is constant only between 50-250 cycles/sec. To verify the theory,[20,22] a higher frequency constancy in the value of ψ and its decrease at low frequency with the square root of frequency was needed. This has been made possible using improved experimental technique[23,24] for measurement at platinum-aqueous electrolyte interfaces.

The results obtained with 0·002 M Fe^{++}, 0·002 M Fe^{+++} in 0·5 M H_2SO_4/Pt at varying frequencies of a.c. at 4 mv show that ψ is constant for frequencies ranging from 500-5000 cycles/sec. At lower frequencies ψ varies with $\sqrt{\omega}$ (where $\omega = 2\pi$ f, f being the frequency of the a.c. used) and becomes 0 when ω is 0. These results are in complete agreement with the theory.[20,22] The results obtained at frequencies below 500 cycles/sec., have been used to calculate the rate constant at equilibrium; the diffusion coefficient of the reactants in the same medium (supporting electrolyte) being determined by the fritted glass diaphragm cell method.[25] At any particular a.c. frequency and potential, the redoxokinetic potential is independent of temperature.

From the values of transfer coefficients and rate constants at different temperatures, the energy of activation and frequency factor of the redox system is obtained.[24] The former are independent of the concentration of the reactants[26] when it is less than 0·002 M. The values of transfer coefficient and rate constant for the above system are 0·586 and 0·048 c.m./sec., respectively.

The transfer coefficients[27] of $Fe(CN)_6^{---}$ and $Fe(CN)_6^{----}$ (0.001 M equimolecular concentration) in 1·0 N-KCl, 1·0 N-KNO_3 and 1·0 N-K_2SO_4 are equal, the value being 0·49 at 35°C. The rate constant at equilibrium in 1·0 N-KNO_3 having 0.001 M concentration of the redox couple is 0·066 cm./sec., at 35°C. The value of α in 1·0 N-KBr and 1·0 N-KI is 0·50 and 0·47, respectively, at 35°C.

On addition of non-polar liquids[28] to the ferrous-ferric system, the transfer coefficient is enhanced, but the rate constant remains practically unaltered; with benzene transfer coefficient is 0·699 and with toluene it is 0·686 at 35°C. The addition of pH indicators[29] also increases the transfer coefficient of the system, the values with bromo-thymol blue, methyl red, and bromo-cresol purple or thymol blue, being 0·669, 0·663 and 0·643, respectively at 30°C. The transfer coefficient decreases on addition of simple surfactants,[30] detergents[31] or macro-molecules[32] like insulin, invertase and egg albumin and increases on addition of amyl alcohol, gelatin and inulin. On addition of (i) chloroform, acetone, isobutyl alcohol and isopropyl alcohol, the values of transfer coefficient are 0·575, 0·569, 0·556 and 0·541, respectively, at 19°C; (ii) lisapol N, fixanol C (cetyl pyridinium bromide), teepol neutral, and insulin or invertase, egg albumin, they are, respectively, 0·573, 0·566, 0·526, at 35°C and 0·559, 0·572 at 30°C; (iii) amyl alcohol, gelatin and inulin they are 0·613 at 19°C, 0·591 and 0·630 at 30°C, respectively.

When 0·4gm mol/litre of acetone and 0·002% fixanol C are, respectively, added to 0·001 M Fe^{++}, 0.001 Fe^{+++} in 1·0 N, H_2SO_4/Pt, the rate constants are 0·055 and 0·12 cm./sec., at 35°C.

In the quinhydrone system, the transfer coefficient increases with the increase[33] in βH of the medium.

Recently, Barker[34] has demonstrated that the phenomenon of Faradaic rectification can be 'exploited' to measure high rate constant even of the order of 150 cm/sec. This new technique—High Level Faradaic Rectification differs from the radio frequency polarography (also termed as Low level Faradaic Rectification) in that the latter is concerned with small potential variation ($\sim$ 5mv.). *Both HLFR and LLFR* are based on the combination of charge injection technique and the phenomenon of faradaic rectification.

Recently this new application of redoxokinetic effect, *HLFR* has enabled (i) the measurement of rate constants of the order of 100 times larger than those that can be measured by any of the other known methods (c.f. galvanostatic, potentiostatic, faradaic impedance etc.), (ii) the determination, for the first time, the homogeneous rate constants of fast dissociation and recombination reactions for a number of organic acids in aqueous solution and (iii) has given experimental evidence for some common properties for a number of weak acids of different constitution. Thus it seems certain that the potentialities of the HLFR method are considerable.

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COLLOID ELECTROLYTE BOUNDARY AND KOHLRAUSCH'S RELATION $T_A/C_A=T_B/C_B$ FOR IONIC BOUNDARIES—PART III.

(ELECTROPHORESIS OF Sb_2S_3 Sol)

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SUMMARY

The behaviour of colloid-electrolyte boundary between positive sols of Cr and Fe Hydroxides and various concentrations of Li Cl supernatant solution, resembled the behaviour of purely ionic boundaries and could be explained, as shown in Parts I & II of this series, in the light of Kohlrausch's relatiod $T_A/C_A=T_B/C_B$ for a sharp moving boundary between two electrolytes A & B. The present paper deals with our studies extended to the boundary between the negative sol of Sb_2S_3 and various concentrations of the supernatant liquid, acetic acid. The departure from Kohlrausch's relation when the acetic acid has higher conductivity than the sol has been discussed and compared with the similar observations for positive sols.

INTRODUCTION

One of the important aspects of Kohlrausch's conclusions regarding the adjustment of the concentration of the indicator ion which should automatically take place according to relation $T_A/C_A=T_B/C_B$ was studied and confirmed by Longsworth (1932) for ionic boundaries. [T_A and T_B are the transport numbers, C_A and C_B the concentrations of the leading and the indicator ions A and B respectively forming a sharp boundary so that the faster (leading) ions are followed by slower (indicator) ions.] Longsworth observed that these adjustments are ensured only when the initial concentrations of the two ions forming the boundary do not differ considerably. References to such studies for colloid electrolyte boundaries are not available and it was, therefore, considered essential to study this aspect, in order to obtain reliable information about ξ-potential and charge of the colloidal particles by boundary method.

Our experiments with positive sols of Fe and Cr hydroxides communicated in parts I and II of this series, showed that the leading colloid particles also appear to suffer concentration changes when they are followed by the indicator ions having high concentration. The values obtained for their electrophoretic velocity in such cases were found to be much higher than those obtained with lower or equiconducting concentrations of the indicator ions.

The results obtained with negative sol of Sb_2S_3 sol and various concentrations of the acetic acid as supernatant liquid also show a concentration adjustment of the leading ion, quite contrary to the fact that it is only the indicator ion whose concentration is adjusted according Kohlraush's theory. The values of electrophoretic velocities obtained from such cases show that in contrast to positive sols, they are far less than those obtained with lesser or equiconducting concentrations of acetic acid (fig. 1).

EXPERIMENTAL

(a) Preparation of Sb_2S_3 Sol : A fairly concentrated sol was obtained by passing purified H_2S gas slowly through 400 cc. of distilled water in which 2% solution potassium Antimonyl Tartrate was added drop by drop till the sol. just started getting translucent. Excess of H_2S was expelled by a slow current of purified hydrogen and the sol was purified against running distilled water.

(b) The apparatus, technique used and calculations of the potential gradient under which the boundary is supposed to move (Kruyt 1928) were same as described in Parts I and II of this series.

OBSERVATIONS AND DISCUSSIONS

The results obtained by using various equiconducting supernatant liquids were significant to suggest that equiconducting acetic acid which produced a sharp descending boundary with the sol under study can be considered to be a suitable supernatant liquid in view of the criterions reasoned out by us (in our earlier communications) from the conclusions of J. N. Mukherjee (1928) and Henry & Brittain (1933).

The effect of gradually increasing the concentration of the supernatant liquid (Acetic Acid) is shown in plates 1, 2 and 3.

In Plate 1 it will be seen that the ascending boundary consists of a yellowish orange colour (when supernatant liquid of small concentration 1/4 times conducting than the sol is used) which deepens on increasing the concentration of the supernatant liquid to $\frac{1}{2}$ times. With equiconducting concentration of the supernatant liquid (Plate 2), the advancing sol column does not differ from the original in colour and thickness. But with further increase in concentration of supernatant liquid used the advancing sol column splits into three distinct layers of different colour intensities, namely faint yellow, deep orange and reddish orange. On the other hand the descending boundary shows a gradual increase in the intensity of the colour (faint yellow deep red) with time when the concentration of the supernatant liquid is small ($\frac{1}{4}$ times conducting to equiconducting concentrations). The increase in the concentration of the supernatant liquid beyond this concentration changes the behaviour of this boundary altogether and it is now found to change in colour from reddish orange to yellowish orange and loose its shape as well.

The behaviour of both these boundaries shows a considerable departure from what is expected (from their analogy with the ionic boundaries) according to the Kohlrausch's regulating function $T_A/C_A = T_B/C_B$. The first important aspect of this theory is that the concentration of the indicator ions (following faster leading ions) should automatically adjust itself according to the above relation producing a sharp and stable boundary. But the changes in the concentration of the descending sol column where the sol particles behave as leading ions, point out to the possibility of the mutual adjustment of concentration of the leading and the indicator particles in a colloid-electrolyte boundary. This confirms our earlier conclusions obtained from the behaviour of the colloid-electrolyte boundaries of positive sols.

The ascending boundary also shows a peculiar behaviour with higher concentrations of the supernatant liquid and its splitting into three distinct shades seems to be abnormal. Table 1 summarises the values of the electrophoretic velocities obtained with the various concentrations of the supernatant liquid. The values obtained show that with higher concentrations of the supernatant liquid the electrophoretic velocity is diminished and with equiconducting and smaller concentrations of the supernatant liquid, practically same values are obtained. This is in contrast to that observed with positive sols of ferric and chromic hydroxides, where, with the higher concentrations of the supernatant liquid, the electrophoretic velocity is found to increase as shown in fig. 1, where the different values of electrophoretic velocity obtained with various conductivities of the supernatant liquid (*viz*., equi, half, two or three times conducting solutions represented by C, ½C, 2C or 3C etc.) are plotted.

TABLE 1

Sb_2S_3 Sol : Descending boundary

Concentration of the supernatant liquid. Acetic acid.	3C	2C	C	1/2 C	1/4C
Electrophoretic velocity Cms/Sec/unit pot. grad. ($X10^{-5}$)	32·2 Fig. 58	41 Fig. 59	44·5 Fig. 60	46·3 Fig. 61	44·8 Fig. 62
ξ-Potential (Volts $X10^{-3}$)	38	49	53	55	53

It is thus concluded from these observations that Sb_2S_3 sol which is known to be much less stable compared to the Fe and Cr hydroxide sols, colloid electrolyte interactions in the electric field seem to play a greater role, leading to a considerable departure from its analogy with the purely ionic boundaries. More work so as to ellucidate the nature and mechanism of the process involved in the migration of colloid-electrolyte boundary is under progress.

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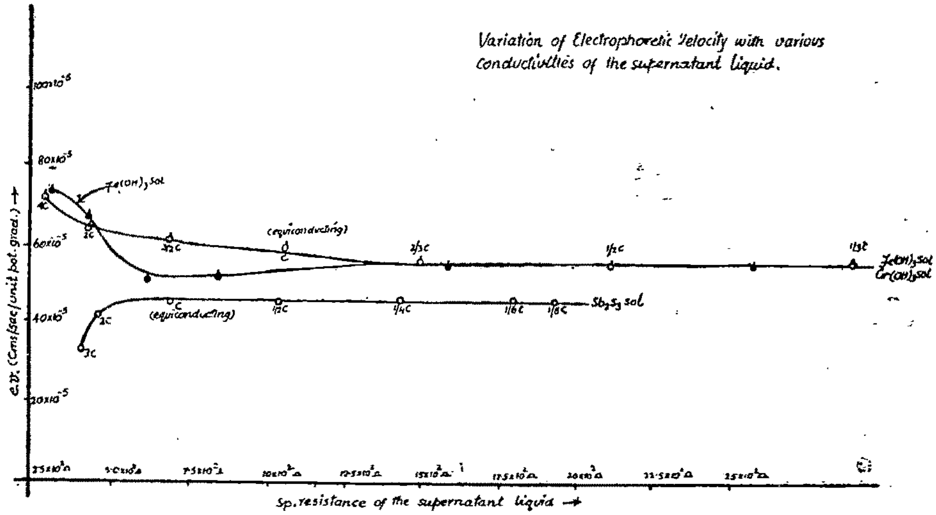
Variation of Electrophoretic Velocity with various conductivities of the supernatant liquid.
e.v. (Cms/sec/unit pot. grad.) →
100×10⁻⁵
80×10⁻⁵
60×10⁻⁵
40×10⁻⁵
20×10⁻⁵
Fe(OH)₃ sol
Fe(OH)₃ sol
Cr(OH)₃ sol
Sb₂S₃ sol
(equiconducting)
(equiconducting)
4C
2C
3/2C
C
2/3C
1/2C
1/3C
3C
2C
C
1/2C
1/4C
1/6C
1/8C
2.5×10³ Ω
5.0×10³ Ω
7.5×10³ Ω
10×10³ Ω
12.5×10³ Ω
15×10³ Ω
17.5×10³ Ω
20×10³ Ω
22.5×10³ Ω
25×10³ Ω
Sp. resistance of the supernatant liquid →

Fig. 1.

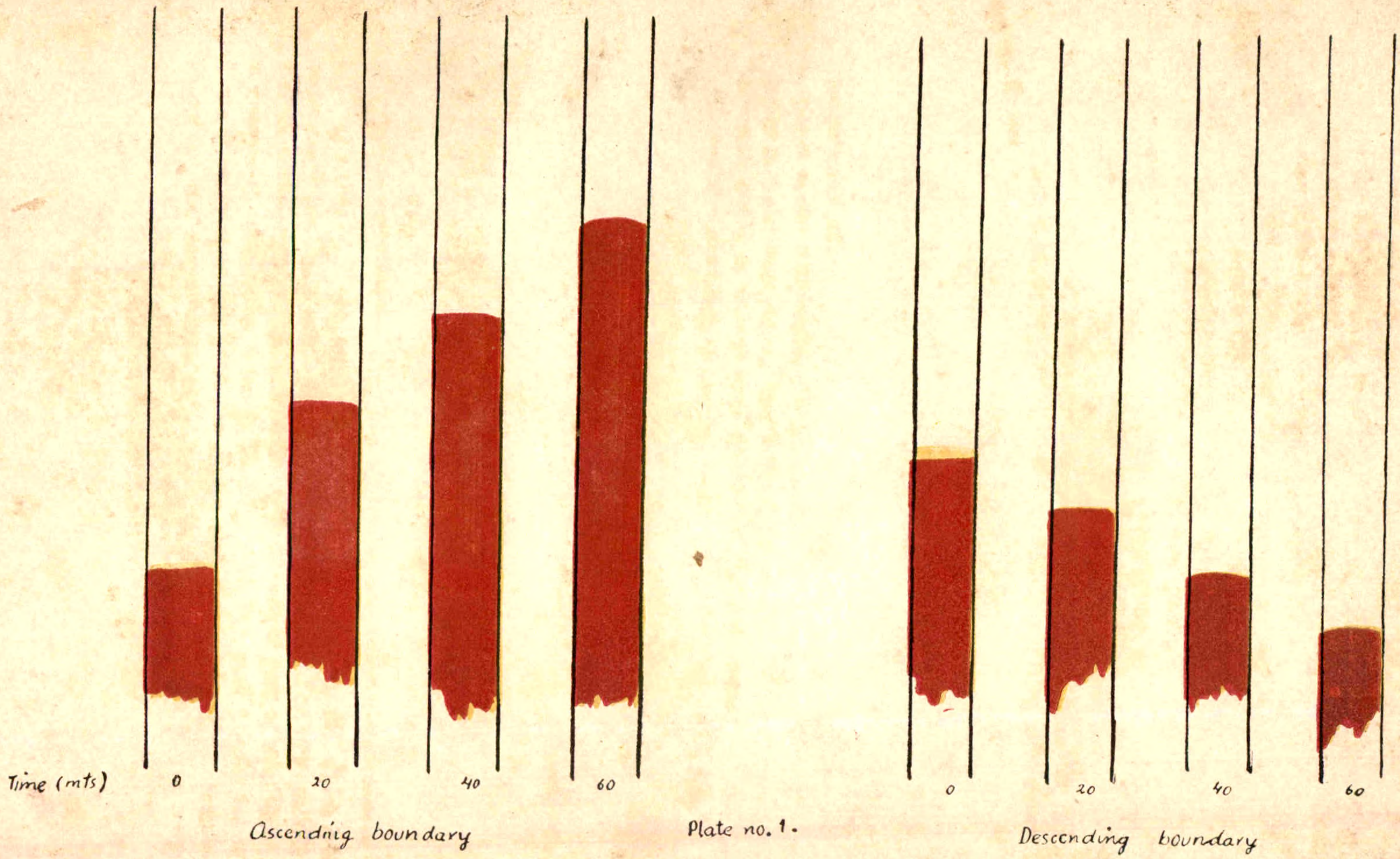

Plate no. 1.

Sb_2S_3 sol : Acetic acid solution of concentration lower than the equiconducting

(Similar results with ½ and ¼ times conducting solutions of acetic acid)

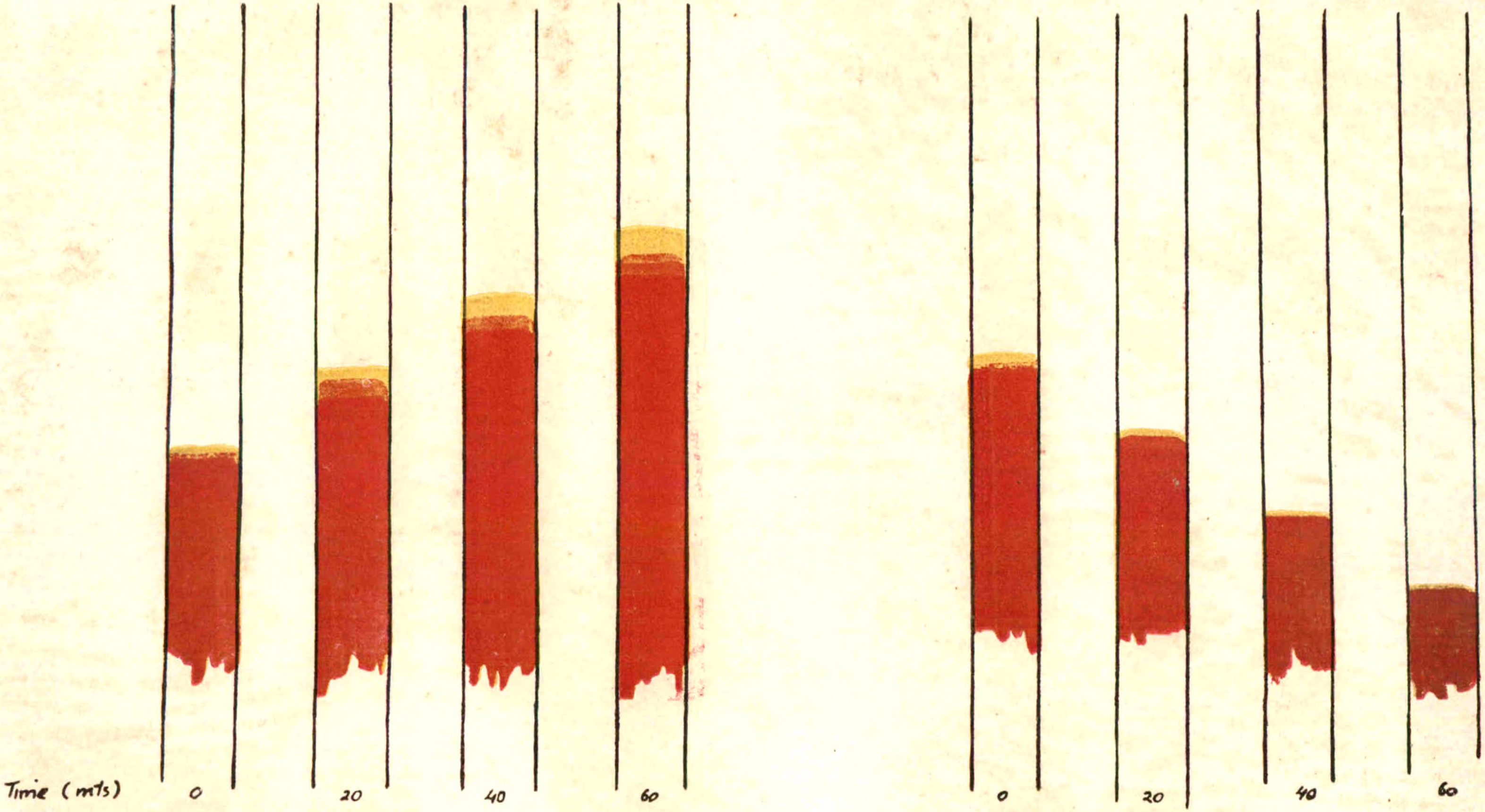

Plate no. 2.

Sb_2S_3 sol: Equiconducting Acetic acid solution supernatant liquid.

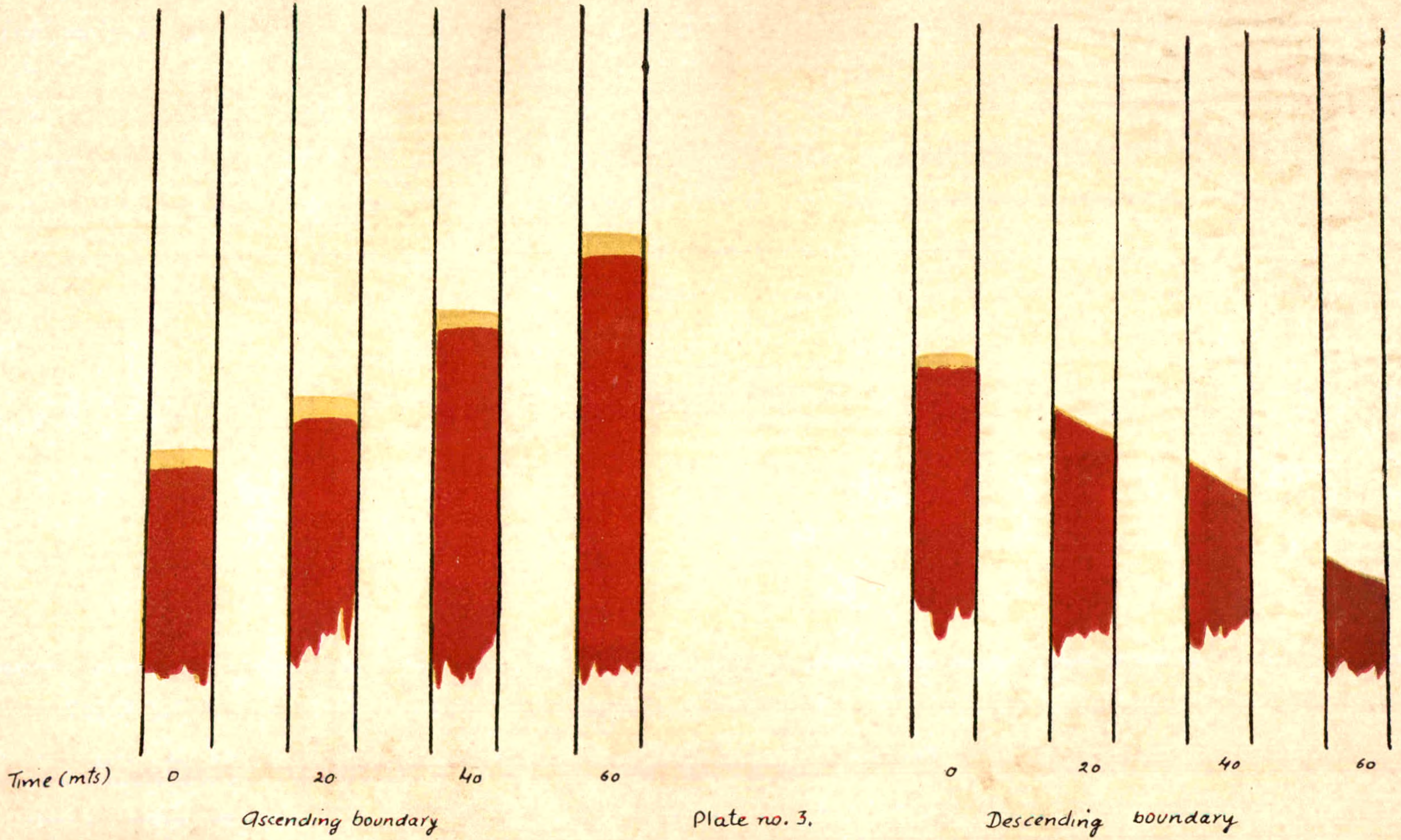

Plate no. 3.

Sb_2S_3 sol: Acetic acid solution of concentration greater than the equiconducting

(Similar results with 2 and 3 times conducting solutions of acetic acid)

SURFACE FILMS OF BROMOCRESOL PURPLE

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INTRODUCTION

Earlier work on the study of the kinetics of the formation of adsorption films of surface active solutes at the surface of solutions of benzopurpurin 10B, nekal BX, casein[1], thymol blue, bromophenol blue and bromothymol blue[2] have shown features which are characteristic of various systems. It was therefore considered of interest to advance the work to few more systems. The present work deals with the study of the surface films of bromocresol purple.

EXPERIMENTAL

1. *Solutions used* : One gram of bromocresol purple indicator, B. D. H. make, was ground in an agate mortar with 37 ml of 0·05N sodium hydroxide and was made up to a litre by distilled water. The stock solution was filtered through Whatman No. 42 filter paper and was used for preparing the solutions of the following concentrations : 0·05%, 0·025%, 0·0125% and 0·00625% by weight. The actual concentration of the stock solution was determined by evaporating a definite volume, in duplicate, in a porcelain dish, it was found to be 0·128%.

The pH of the solution was adjusted to 2 by adding the required quantity of pure hydrochloric acid. The pH 5 was maintained by using the acetate buffer. The correct pH was found by Backman pH meter model H2.

Other chemicals used were of analar quality of B.D.H.

2. *Experimental Technique* : The film balance used was improvised in the laboratory using DU NOUY TENSIOMETER.[2] The methods for measuring (a) variation of surface tension with time, (b) force-area curves, (c) rate of accumulation and (d) effects of electrolytes and non-electrolytes, are the same as described in the previous work.[2]

DISCUSSION OF RESULTS

1. *Variation of surface tension with time* : An examination of the curves in fig. 1 shows that the surface tension of bromocresol puple solution at pH2 falls off very rapidly during the first 2-3 minutes and thereafter the fall is slow. It appears that there is no potential barrier for initial accumulation of bromocresol purple and therefore there is a rapid fall of surface tension. As soon as the surface gets covered by the initially accumulated molecules, a charged layer is developed, as the bromocresol purple is singly negatively charged at this pH which slows down the accumulation until equilibrium is attained.

2. *Force-Area Curves* : The surface films formed by accumulation of bromocresol purple at the surface were found to exhibit the properties of the insoluble substances as has been observed with many other systems earlier.[3] The examination of the force-area curves in fig. 2, shows that we are dealing with a single phase film. The compressibility diminished only very slowly with increase of pressure. Even at the highest pressure the lowest compressibility observed for this system is 0·09 cm. per dyne which is much higher than the corresponding values for single phase films with other systems, even when the film pressures of the latter systems are comparatively low. The films obtained from different concentrations of the indicator are similar in behaviour as is clear from the similarity of the force-area curves for different concentrations.

3. *Rate of accumulation* : An examination of the curves fig. 3 shows that there is a progressive accumulation of bromocresol purple with time. The initial rate of accumulation is invariably fast and slows down afterwards; also the accumulation is faster in more concentrated solutions. It is to be noted that all areas have been measured at a surface pressure of 2 dynes per centimeter against a one minute old reference surface. Since the one minute old surface has a lower surface tension with more concentrated solution, it is clear that the areas are being measured at higher absolute pressures. If the areas are measured at the same pressure throughout, the values for accumulation would be much higher in the case of solutions of higher concentrations.

4. *Effect of pH on the variation of surface tension with time and rate of accumulation* : The effect of pH on the variation of surface tension with time is very interesting. From fig. 4 curves 1 and 2 it is seen that the electrical potential barrier is slightly more effective at pH 5 than at pH 2. This probably is due to bromocresol purple having doubly negatively charged ions at higher pH values. That the electrical potential barrier is responsible for the slowing down of accumulation is proved from the observations in fig. 4 curves 3 and 4 which show the effect of neutral salts.

An examination of fig. 5 curves 4 and 5 shows that the rate of accumulation is raised by decrease in pH. The H^+ ions on account of their small size have a very high deforming action on the anions. The concentration of H^+ ions would therefore have a large effect on the zeta potential of colloidal systems. The same is true here also.

5. *Effect of electrolytes on the variation of surface tension with time and rate of accumulation* : An examination of fig. 4 curves 3 and 4 shows that the addition of M/10 KCl to 0·025% bromocresol purple (pH=2) steps up the variation of surface tension with time tremendously so much so the surface tension obtained within two minutes in presence of M/10 KCl is less than that obtained in 10 minutes with the solution free from the salt. Also it is clear that $BaCl_2$ even at M/100 concentration is much more effective than M/10 KCl. This is due to divalent barium ions having a direct effect on the negatively charged films and bringing down the charge density considerably.

An examination of fig. 5 curves 1 and 2 shows that the rate of accumulation of 0·025% bromocresol purple solution (pH=2) is very much enhanced by the addition of M/100 $BaCl_2$ and M/10 KCl, respectively; it is quicker in presence of $BaCl_2$ than of KCl. This increase in the rate of accumulation by electrolytes is due to (i) the contraction of the electric double layer and (ii) the formation of aggregates at higher ionic strengths, for it is shown that polymerisation should bring an increase in the rate of accumulation.

6. *Effect of addition of non-electrolytes on the rate of accumulation* : The capillary inactive non-electrolytes like cane sugar have no measurable effect on the rate of accumulation even when present to the extent of 0·5%, but the capillary active non-electrolytes like ethyl and amyl alcohols diminish the rate of accumulation even when present in small concentrations (see fig. 5 curves 6 and 7). This action of alcohols with regard to accumulation depends on the fact that they effectively destroy the foam obtained in such solutions.

ACKNOWLEDGEMENT

The authors take this opportunity to thank Sri N. Abraham, Principal, Christ Church College, Kanpur, for his interest in the work.

SUMMARY

The force-area curves of bromocresol purple solutions show that the films obtained from different concentrations have the same structure at equal surface pressures. The solutions of bromocresol purple show a variation of surface tension with time, the rate becomes slow after some time, indicating the existence of electrical potential barrier. This barrier is more effective at higher pH values. The addition of neutral salts annul the effect of the potential barrier. The surface active non-electrolytes inhibit the rate of accumulation.

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4. Same as reference 1. (b).

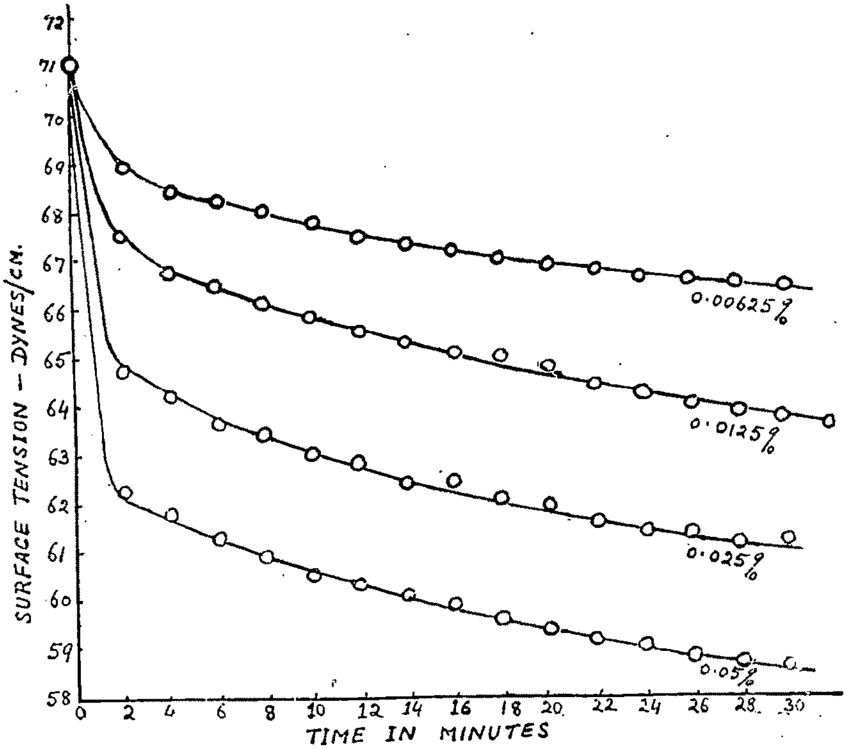

Fig. 1. Variation of surface tension with time of Bromocresol Purple Solution, pH=2.

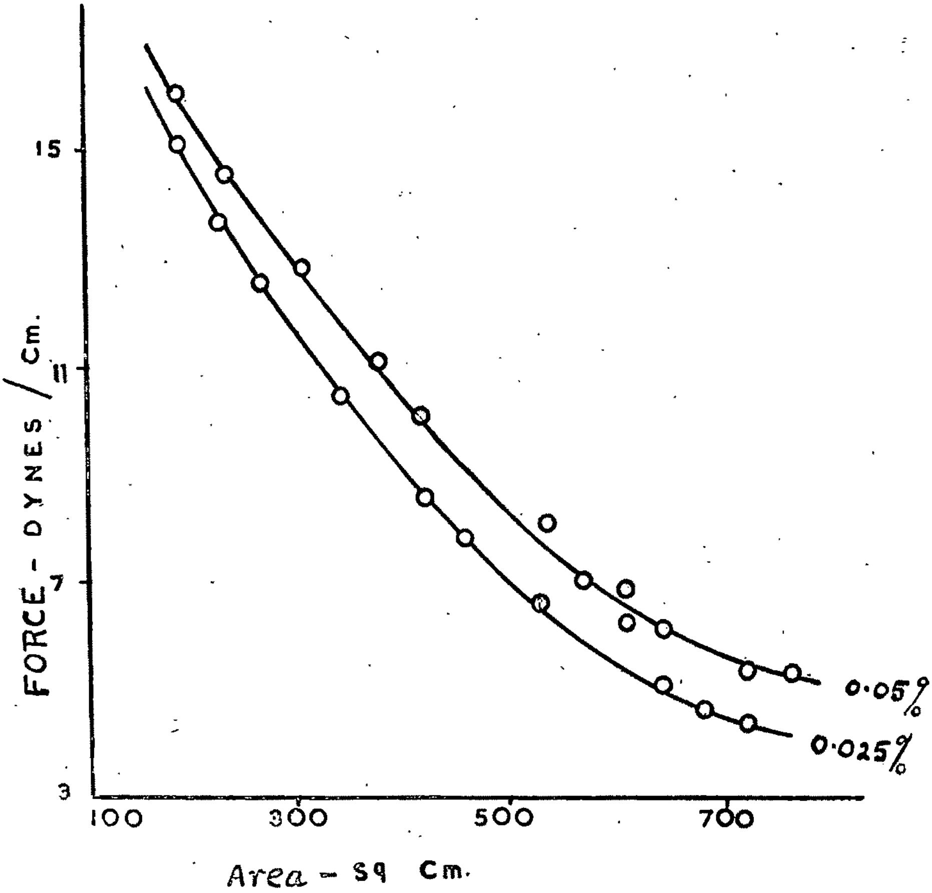

Fig. 2. Force-area curves pH=2

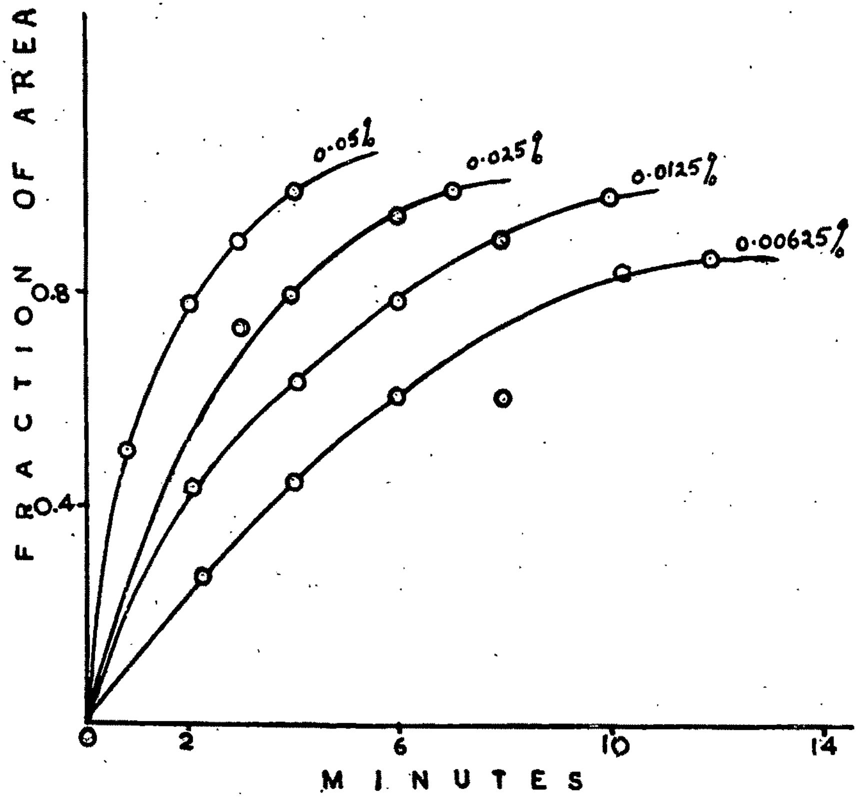

Fig. 3. Rate of accumulation of Bromocresol Purple, pH=2.

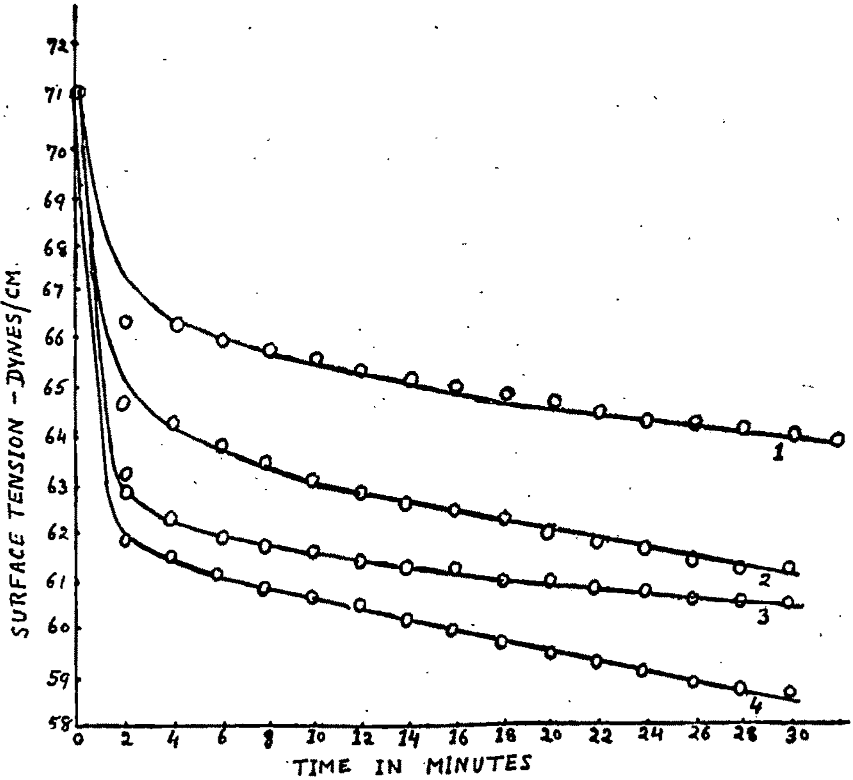

Fig. 4. Effect of pH and Electrolytes on the variation of surface tension with time of 0·025% B.C.P. solution. (1) pH=5 (2) pH=2 (3) 0·1M KCl, pH 2 (4) 0·01M $BaCl_2$, pH 2.

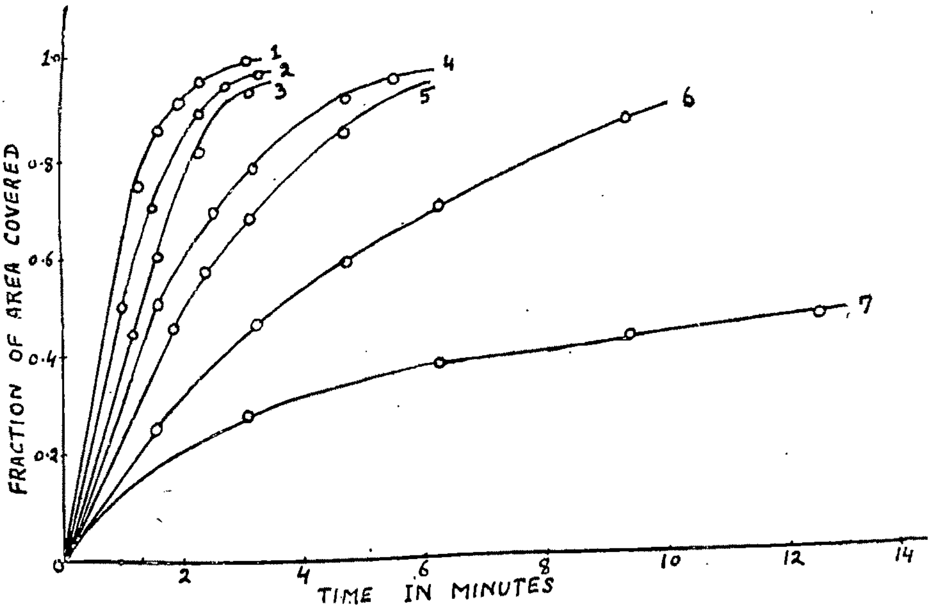

Fig. 5. Rate of accumulation of 0·025% Bromocresol Purple. Effect of (1) 0·1M KCl, pH 2, (2) 0·01M $BaCl_2$, pH 2, (3) 0·01M $BaCl_2$ pH-5, (4) pH=2, (5) pH=5. (6) 2% Ethyl Alcohol and (7) 0·3% Amylalcohol.

ABO BLOOD GROUP FREQUENCIES AT AGRA

[AN ANALYSIS OF 14468 CASES]

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Although Landsteiner observed the variation in the blood groups of normal individuals belonging to the same species in the year 1900, it was not till 1919 that on the basis of the analysis of blood groups of soldiers of several nationalities, Hirszfeld and Hirszfeld pointed out the significant differences in the distribution of blood groups amongst individuals from different nations. The search for an explanation for the rarity or predominance of one or more of these groups in different races has engaged the attention of various investigators since then. Numerous papers have been published and extensive data is available on ABO blood group frequencies in different regions of the world including the Indian region.

With the realisation of the probable relationship existing between different blood groups and various diseases like peptic ulcer, gastric carcinoma, pernicious anaemia, diabetes mellitus etc., it has become necessary to work out the incidence of different ABO blood groups in a particular population irrespective of castes, nationalities or races, so that the same could serve as adequate control in any study on the relation of blood groups to disease. Table 1 shows the distribution of ABO groups in various parts of the country as reported by various authors. The size of the sample in most of the studies is not big. Because of the paucity of reports on ABO group frequencies in a large series of mixed population from this part of the State, results obtained on analysis of data from 14468 cases are reported here.

TABLE 1

Distribution of ABO groups in Non-tribal population in various states in India.

State	Author	Year of study	No. of cases analysed	Blood Groups (per cent)			
				A	B	O	AB
Punjab	Pathak	1959	550	21·27	40·36	28·73	9·64
Rajasthan	Goyal & Anand	1953	600	24·50	35·84	32·50	7·16
Uttar Pradesh	Malone & Lahiri	1929	2357	24·50	37·20	30·20	8·10
Bihar	Mishra	1955	3000	21·46	37·12	33·06	8·36
Bengal	Sen et al	1959	2200	22·23	37·18	33·09	7·41

(*Continued*)

TABLE 1 (*Contd.*)

Distribution of ABO groups in Non-tribal population in various states in India.

State	Author	Year of study	No. of cases analysed	Blood Groups (per cent)			
				A	B	O	AB
Assam	Shukla	1958	2594	26·75	29·26	37·00	7·05
C.P. & Berar	House & Mahalanobis	1953	118	21·19	38·14	22·97	12·71
Bombay	House & Mahalanobis	1953	1168	29·20	28·25	31·76	10·79
Gujrat	Anklesaria et al	1960	2411	24·10	35·90	32·10	7·90
Madras	Ayer & Mummurthi	1953	1000	23·00	29·10	42·80	5·10
Kerala	Bird et al	1962	1900	22·63	25·26	48·95	3·16

MATERIAL AND METHODS

The present series of 14468 individuals includes doctors, medical students, nursing staff, laboratory technicians, hospital patients, convicts from the local Jails and voluntary donors registered at the Blood Bank Laboratories, S.N. Medical College, Agra. Data from professional donors registered at the Blood Bank Laboratories have not been included in the series. The blood grouping was done by the tile technique using 2% cell suspension of red cells and standard antisera. Gene frequencies were calculated according to the following:—

$$r=\sqrt{\frac{\text{O}}{\text{N}}}$$

$$p=1-\sqrt{\frac{\text{O}+\text{B}}{\text{N}}}$$

$$q=1-\sqrt{\frac{\text{O}+\text{A}}{\text{N}}}$$

Where O, A and B represent the number of persons with O, A and B groups respectively and N represents the number of individuals in the sample analysed. r, p and q represent the gene frequencies of O, A and B genes respectively. Corrected gene frequencies were calculated using Bernsteins formula.

$$r'=\left(1+\frac{\text{D}}{2}\right)\ \left(r+\frac{\text{D}}{2}\right)$$

$$p'=p\left(1+\frac{\text{D}}{2}\right)$$

$$q'=q\left(1+\frac{\text{D}}{2}\right)$$

Where $D=1-(p+q+r)$ and r', p' and q' being the corrected gene frequencies of O, A and B genes respectively. Expected frequencies for various phenotypes were calculated as follows:—

Phenotype	*Expected frequencies*
O	Nr'^2
A	$N(p'^2+2p'r')$
B	$N(q'^2+2q'r')$
AB	$N(2p'q')$

X^2 test was used to test the significance of these frequencies applying the formula:

$$X^2=\sum^{N}\frac{(O_i-E_i)^2}{E_i}$$

OBSERVATIONS

Table 2 shows the distribution of A, B, O and AB blood groups in 14468 individuals from Agra. 39·50% of the individuals belong to B group.

TABLE 2

Showing the distribution of ABO group amongst 14468 individuals.

Phenotype	Number observed	Percentage
A	3296	22·78
B	5714	39·50
O	4063	28·08
AB	1395	9·64

Table 3 shows the distribution of observed and expected phenotype frequency in different sexes.

TABLE 3

Showing phenotype frequency according to sex.

Sex	Male				Female			
Phenotype	Number		Frequency		Number		Frequency	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expectep
A	1997	1953	22·43	21·94	1299	1229	23·34	22·08
B	3409	3487	38·29	39·17	2305	2239	41·41	40·23
O	2629	2561	29·53	28·77	1434	1489	25·78	26·75
AB	867	901	9·75	10·12	528	609	9·48	10·49

X^2 test gave a value of 7·11 for males and 17·34 for females, the tabular value at 5% level for 3 degrees of freedom being 7·815.

Table 4 shows the gene-frequency distribution according to different sexes and in the total sample. No significant variation was observed in the distribution of various blood groups in different sexes.

TABLE 4

Showing gene frequency distribution.

Genes	Sex		Total sample
	Male	Female	
p	·1757	·1816	·1786
q	·2879	·3012	·2876
r	·5364	·5172	·5338

DISCUSSION

Besides the importance of blood groups in anthropology, blood transfusion, antenatal care and genetics, further interest in blood groups has been aroused because of the probable relationship existing between blood groups and various diseases. First attempts to correlate the ABO groups with a variety of diseases were made by Buchanan and Higley in 1921. Subsequently although a number of workers attempted to correlate blood groups with disease, it was the pioneer work of Aird, Bentall and Fraser-Roberts in 1953 which focussed the attention of scientific workers on the problem once again. The evidence for an association between ABO groups and susceptibility to disease has been shown to be quite convincing for some diseases and fairly suggestive for others (Race & Sanger 1959).

For studies of this type it is necessary to select properly the control group against which to match the blood group frequencies observed in different diseases. Controls can be selected in two ways. The series for general population of the areas concerned may be used or the figures for patients suffering from other diseases at the hospital concerned may be utilized. Usually in the preparation of series for general population of the area concerned, the data is derived from the list of blood bank donors. If the hospital patients and donor controls are not drawn from entirely corresponding populations it might lead to significant variations in results. This is particularly true for this part of the country where the majority of blood donors are professional and are derived from different parts of the country (Mital, 1962). Allan (1954) has pointed out that even when the donors are typical of the general population they may not be representative. Therefore, the method of choice for selecting persons for control series should be to secure figures from the general population rather than from professional donors.

It has been a general observation that gene B is very high in the Indogangetic valley and as one moves towards the South the frequency of B decreases and that of gene O increases. Moving towards East the frequency of gene B decreases while that of genes A and O is apparently increased. The frequency of gene B in this series was 28·76% and compares well with that reported by Malone and Lahiri (1929)—26·1% and Mourant et al (1958)—25·23%. Macfarlane has suggested hybridisation as a significant factor in determining a concentration of B among mixed castes.

SUMMARY

An analysis of ABO blood groups of 14468 individuals has been reported from Agra. 39·50% persons belonged to B group. The importance of deriving ABO blood group frequencies from general population rather than from professional blood donors has been pointed out.

ACKNOWLEDGMENTS

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ACHOEA JANATA LINNAEUS THE CITRUS FRUIT SUCKING MOTH (LEPIDOPTERA-NOCTUIDAE)

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Achoea janata Linn. commonly known as castor semilooper in India is widely distributed throughout citrus growing countries of the world. It is mainly a pest of castor (*Ricinus communis*), but has been recorded from several other cultivated and non-cultivated plants of various families. Fletcher (1914) reported it from South India on Pomegranate (*Punica granatum*), Lever (1941) in Figii on Rose (*Rosa* spp.), Van (1946) in Honolulu and Hawaii on Dudhi (*Euphorbia hirta*). In addition the authors have also recorded Hazardana (*Phylanthus neruri*), Latzira (*Achranthus aspra*) and pipal (*Ficus religiosa*) as new host plants of this pest.

Ayyar (1944) reported that *Achoea janata* is an important pest of castor in Deccan, but its importance as fruit sucking moth is not known. At Kanpur we noted twelve different species of fruit sucking moths and *Achoea janata* stood third in order of their presence in the garden. Golding (1945) in Nigeria recorded the *Achoea* spp. attacking ripe and ripening mango, guava, tomato, fig and citrus fruits. But we found that the moths of *Achoea janata* are the serious pest of all the citrus fruits only, namely the sweet lime (*Citrus limetta*), grape fruits (*Citrus paradisi*) and malta (*Citrus cinensis*).

The mouth parts of the adult moth are stout with saw like long proboscis composed of two elongated galeae. The proboscis is adapted to puncture the ripening fruits of citrus. Rakshapal (1945) at Gwalior, recorded that *Achoea janata* attacks after mid night, Golding (1945) in Nigeria mentioned that the moths of *Achoea* spp. pierce the fruits throughout the night and until about 10·30 a.m. on dull days, but during the present course of investigations the moths were invariably present in the citrus orchard after dusk. It alights and settles on a fruit, then starts searching a suitable point with the help of apex of its proboscis. In majority of cases the upper half portion of the fruit is selected. After searching a proper place, the proboscis is thrust through the rind of the fruit with slow drilling action.

Effect of piercing and sucking on citrus fruits:

The moths of *Achoea janata* generally do not attack green fruits, but in the absence of desired food material unripe fruits are not left free. The injury in the ripe and ripening fruits is initially a simple puncture which can only be seen by expert eyes. An affected fruit on squeezing oozes out a fermented frothy juice from the puncture caused by the moth.

Susainathan (1924) observed on an average 9-10 punctures on a single fruit. At Kanpur we found 6-15 punctures on a single fruit. The fruits which are damaged by these moths begin to rot near the puncture and brown roughly circular area, surrounding the puncture is formed. An injured fruit turns yellow prematurely and falls down with the slightest disturbance. It was also noted that the fruits which drop prematurely due to attack of these moths are further subjected to the attack of certain bacterial and fungal diseases. Such fallen fruits rot in a day or two and become absolutely unfit for human consumption.

Effect of artificial puncturing on citrus fruits:

An experiment was conducted by artificial puncturing the grape fruits (*Citrus paradisi*) with a syringe and a little juice was extracted from each puncture in the orchard of Govt. Agricultural College, Kanpur. One to sixteen punctures were made and depth adjusted at 1″, 3/4″ and 1/2″. It was noticed that as the number of punctures increased, the number of fruit drop also increases and the depth of the punctures makes a negligible effect on the drop of fruits.

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BOTRYODIPLODIA THEOBROMAE—A MANGO FRUIT ROT ORGANISM IN INDIA

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During the survey for market diseases of fruits at Naini Tal (India), the authors came across many diseased mango fruits which had large water soaked irregular lesions of black colour. The analysis of these rotted mango fruits yielded a fungus which was later identified as *Botryodiplodia theobromae* Pat. The type culture of the fungus was deposited at the Commonwealth Mycological Institute, Kew, London (No. I.M.I. 91176).

The fungus grew rapidly on potato dextrose agar medium forming regular and circular colonies. The colour of the medium changed from straw yellow to dark olive and finally to black. The mycelium which was at first cottony and hyaline became olive and then black within 4 days of growth. Pycnidia could not be observed even in one year old cultures.

The pathogenicity of the fungus was tested and among various fruits inoculated, the fungus readily attacked Dusseri, Seroli, Amar, Langra and a sour variety of mango fruit, *Capsicum annum*, pear, apple, plum, peach and tomato fruits. The symptoms in general were shallow, water-soaked, black to brownish areas. The pycnidia were formed by the fungus on the infected fruits of mango and pear only.

This is the first report of *Botryodiplodia theobromae* Pat. attacking mango fruits in India. Presumably it causes considerable damage to mango fruits in storage and during transit.

Grateful thanks are due to the Director, C.M.I., Kew, London, for confirming the identification of the fungus.

CHEMICAL INVESTIGATION ON THE STRUCTURE OF *SALMALIA MALABARICA* GUM AND OTHER PLANT GUMS

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Salmalia malabarica gum, commonly known as 'Semul' gum occurs in the Indian cotton tree (*Bombax malabaricum* DC syn. *Salmalia malabarica* Scott and Endl, Fam. Malvaceae) which grows abundantly in India in wild state. It is whitish in appearance, when first exuded, but becomes opaque and darkens to mahogany or blackish colour on drying. Its larger tears are sometimes hollow.

Purification of Salmalia malabarica gum:

The powdered crude gum was dissolved in sodium hydroxide solution, filtered to remove insoluble impurities and the polysaccharide material was recovered by precipitation from its acidic aqueous solution with ethanol. The process was repeated several times to obtain a sample in the form of white amorphous powder having negligible ash content (sulphate ash 0·043%; Equivalent weight 1532; Pentosans 13·9, Pentoses calculated on the basis of pentosans 15·89, Furfural 8·17%). The purified gum was sparingly soluble in water and did not reduce Fehling's solution. Nitrogen, sulpher and halogens were absent.

Homogeneity of the Salmalia malabarica gum:

Homogeneity of *Salmalia malabarica* gum was established by the fractional precipitation with ethanol. The purified gum obtained from the large scale preparation was dissolved in sodium hydroxide solution, acidified and separated in two fractions by adding different quantities of ethanol. In another experiment, a single nodule of the gum was purified three times by the procedure described above. All the three samples were hydrolysed quantitatively and the sugars released were identified by paper chromatographic procedure. Quantitative estimation of the sugars was carried out by oxidising them with sodium metaperiodate. The result of the analysis showed the purified gum sample from a single gum nodule of the crude gum had the same composition as those from large scale preparation, indicating thereby that the gum was essentially homogenous in character.

Acid hydrolysis of the gum:

The purified *Salmalia malabarica* gum was hydrolysed completely with sulphuric acid. The hydrolysate was neutralised with Barium carbonate, filtered and the filtrate was evaporated to a brown syrup. It was extracted exhaustively with methanol to obtain the neutral sugars (Fraction A). The amorphous residue left after extraction with methanol consisted of barium salt of uronic acid (Fraction B). Preliminary paper chromatographic analysis of fraction (A) revealed two strong spots corresponding to arabinose and galactose along with another weak spot, the R_f of which indicates its closeness with rhamnose. Upon partition chromatography on a cellulose column, sugar mixture yielded two crystalline components which were identified as L-arabinose and D-galactose from a measurement of specific rotation and preparation of their characteristic crystalline derivatives. Uronic acid, liberated from the barium salt (Fraction B) was identified as D-galacturonic acid from its paper chromatographic examination, basic lead acetate test and oxidation to mucic acid. For further confirmation about its nature, the methyl ester methyl glycoside of the uronic acid was reduced with sodium borohydride. The reduced product upon hydrolysis yielded only galactose, proving conclusively that the uronic acid component of the *Salmalia malabarica* gum is D-galacturonic acid.

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Quantitative estimation of galactose and arabinose present in Salmalia malabarica gum :

The purified gum was hydrolysed quantitatively with sulphuric acid. The neutral sugars obtained after neutralisation and subsequent treatment of the hydrolysate were separated by paper chromatographic procedure. The individual suagars were eluted from the paper strips with water, oxidised with sodium metaperiodate and the liberated formic acid was titrated with standard alkali. The estimation results indicated that the galactose and arabinose were present in a ratio of 2:1.

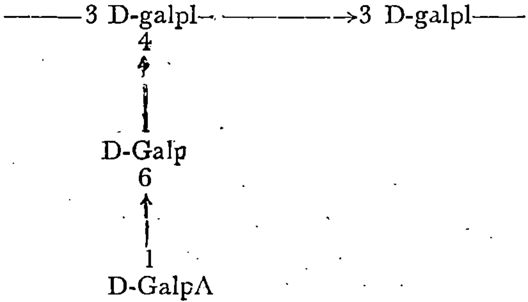
Graded hydrolysis of the Salmalia malabarica gum :

The autohydrolysis of the gum could not be carried out successfully due to its sparingly soluble nature but it was observed that prolonged heating of an aqueous suspension of the gum results in the liberation of small amount of arabinose.

Partial hydrolysis of the gum with 0·2 N sulphuric acid resulted in the production of L-arabinose, rhamnose (traces) and D-galactose along with an aldobiuronic acid. This on further hydrolysis yielded D-galactose and D-galacturonic acid. The structure of the aldobiuronic acid was established from methylation experiments. The fully methylated aldobiuronic acid upon methanolysis and further hydrolysis with aqueous acid yielded 2:3:4-tri-O-methyl-D-galactose and 2:3:4-tri-O-methyl-D-galacturonic acid in nearly equal amounts. The methylated sugar and uronic acid were identified from their specific rotation and by preparing characteristic crystalline derivatives. The identification of the methylated sugars together with the specific rotation of the methylated aldobiuronic acid indicated that the aldobiuronic acid is 6-O-(β-D-galactopyranosyl uronic acid)-D-galactose. The structure of the aldobiuronic acid was further confirmed by reducing the fully methylated aldobiuronic acid with sodium borohydride. The reduced product upon hydrolysis yielded 2 : 3 : 4-tri-O-methyl-D-galactose. The isolation of 2 : 3 : 4-tri-O-methyl-D-galactose shows that the uronic acid portion of the aldobiuronic acid is 2 : 3 : 4-tri-O-methyl-D-galacturonic acid and is linked through C_6 of D-galactose residue.

The structure of the degraded Salmalia malabarica gum :

Controlled acid hydrolysis of the Salmalia malabaric gum yielded a degraded gum together with L-arabinose, D-galactose and rhamnose (traces). The degraded gum which represents the stable nucleus of the gum, upon further hydrolysis afforded D-galactose and D-galacturonic acid. The structure of the degraded gum was established from methylation studies. The fully methylated derivative of the degraded gum upon methanolysis and further hydrolysis with aqueous acid furnished acidic and neutral sugar fractions. The acid component was characterised as 2 : 3 : 4-tri-O-methyl-D-galacturonic acid through its crystalline amide. The neutral sugar fraction was found to consist of 2 : 4 : 6-tri-O-methyl-D-galactose, 2 : 3 : 4-tri-O-methyl-D-galactose, 2 : 6-di-O-methyl-D-galactose together with very small amounts of 2 : 3-di-O-methyl-D-galactose. The identity of all the di- and tri-O-methyl sugars was established from measurements of their specific rotations and m.p.s. of their characteristic crystalline aniline derivatives. The isolations of 2 : 3 : 4-tri-O-methyl-D-galacturonic acid (one mole), 2 : 4 : 6-tri-(one mole), 2 : 3 : 4-tri-(one mole), and 2 : 6-di-O-methyl-D-galactose (one mole) from the methylated degraded gum indicates its branched character and also demonstrates that all the D-galactose and D-galacturonic acid residues are of pyranose structure, and are joined either by 1→3 or 1→6 linkages. A possible structure (I) for the average repeating unit of the degraded gum has been suggested on the basis of the above methylation results and the earlier isolation of 6-O-β-D-galacturonic acid-D-galactose as a graded hydrolysis product of the gum.



(I)

Galp = Galactopyranose
GalpA = Galacturonic acid.

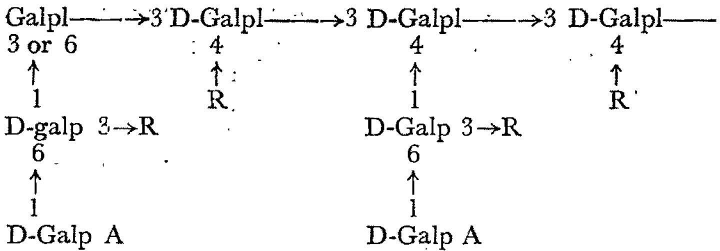
It is seen from the structure (I) that the average repeating unit (I) occurring in the degraded gum carries a main chain of 1→3 linked D-galactopyranose units and the aldobiuronic acid is attached as a side chain to the galacton backbone. The absence of the tetramethyl sugar in the methanolysis product of the fully methylated degraded gum points out that in the degraded gum probably the branching starts from the non-reducing end of the main chain. The structure (I) for the average repeating unit is in agreement with the equivalent weight of the degraded gum.

The mode of union of the sugar units in the major part of the degraded *Salmalia malabarica* gum was further confirmed from periodate oxidation studies. Oxidation of the degraded gum with sodium metaperiodate was found to produce 2·3 moles of formic acid per equivalent with concomitant consumption of 4·3 moles of periodate. The periodate oxidised gum consisting mainly of 1 : 3-linked galactopyranose residue furnished on hydrolysis 1·8 moles of D-galactose per equivalent. The amount of formic acid liberated, consumption of periodate and the amount of galactose residues liberated as a result of hydrolysis of the periodate oxidised gum are in good agreement with that required by structure (I) as proposed for the repeating unit of the degraded gum.

Structural features of Salmalia malabarica gum :

General structural features of *Salmalia malabarica* gum have been found out from the results of methylation experiments. The fully methylated polysaccharide was hydrolysed and the hydrolysate was separated into ether soluble fraction (A) and ether insoluble residue (B). The ether soluble fraction (A) was fractionated upon Whatman No. 3 MM filter paper sheets to give six components of which the following five have been identified. 2 : 3 : 4 : 6-tetra-O-methyl-D-galactose, 2 : 6-di-O-methyl-D-galactose, 2 : 4-di-O-methyl-D-galactose, 2 : 3 : 5-tri-O-methyl-L-arabinose and 2:5-di-O-methyl-L-arabinose. The remaining sixth sugar was obtained in very poor yield and appeared to be a mono-O-methyl-D-galactose from its rate of migration on a paper chromatogram. The ether insoluble fraction (B) was characterised as 2 : 3 : 4-tri-O-methyl-D-galacturonic acid. The identification of the above products showed that the gum contains D-galacto-pyranose units linked through C_1; C_1, C_3 and C_4; C_1, C_3 and C_6 ; L-arabinose units through C_1, C_1 and C_3 and D-galacturonic acid linked through C_1.

In order to explain all the above types of linkages, a provisional structure for the *Salmalia malabarica* gum has been put forward after taking into consideration the structure of degraded *Salmalia malabarica* gum. Since no tri-O-methyl-D-galactose residue has been isolated from the cleavage fragments of methylated *Salmalia malabarica* gums, it is clear that the labile sugar residues are attached in the form of side chains. R to those galactose residues in degraded *Salmalia malabarica* gum which give rise to 2 : 3 : 4-tri- and 2 : 4 : 6-tri-O methyl-D-galactose upon hydrolysis of the methylated degraded gum. The isolation of 2 : 3 : 4-6-tetra-O-methyl-D-galactose, 2 : 3 : 5-tri-O-methyl-L-arabinose and 2 : 3 : 4-tri-O-methyl-D-galacturonic acid shows that these residues are present as end groups in the gum. The point of attachment of these R residues with the stable nucleus of the degraded gum is not yet known. If it is assumed that all the R residues are attached to the main chain in the same manner as the aldobiuronic acid residues, (which is generally the case with majority of the gums) then the structure (2) may be proposed as one of the possible structures for the Salmalia malabarica gum.



R=L-arafl...., D-Galpl—→3 L-Arafi....,
L-Araf 1→3 L-Arafl....
Galp = Galactopyranose
Araf = Arabofuranose
GalpA = Galacturonic acid.

It is clear from the above structure that the gum is highly branched and contains 1→3, 1→4 and 1→6 types of linkages. The highly branched nature of the gum and the presence of 1→3 linkages is further confirmed by periodate oxidation results. Upon oxidation with sodium metaperiodate the gum yields one mole of formic acid per equivalent of the gum with the concomitant consumption of 7·7 moles of periodate. Analysis of the periodate oxidized gum shows that some of the galactose and a few arabinose units have escaped periodate oxidation.

A trial of Salmalia malabarica gum as a settling aid in cane juice clarification:

Like synthetic high polymers, naturally occurring high polymers, namely gums and mucilages have also been used as settling aids in cane juice clarification. The gums containing D-galacturonic acid have been found to give better results than the gums containing D-glucuronic acid in their inner core. Since *Salmalia malabarica* gum contains D-galacturonic acid, its behaviour as a settling aid has been studied. It was observed that *Salmalia malabarica* gum when used in a concentration of 4 p.p.m. gave fastest settling rate, brighter and clearer juice and most compact mud. The flocculating ability of *Salmalia malabarica* gum was next compared with "Jeol" gum and separan A.P. 30 when all these flocculants were used in their optimum doses. The results thus obtained showed, that on an average the settling rate was increased to 300 per cent by separan A.P. 30, 200 per cent by *Salmalia malabarica* gum and 150 per cent by "Jeol" gum. Final mud volume after one hour settling was found to be 20% less in case of separan A.P. 30, 14% less in case of *Salmalia malabarica* gum and 6% less in case of "Jeol" gum.

SUBSIDIARY THESIS

A chromatographic analysis of non-nitrogenous organic acids present in raw juice, clarified juice and molasses.

The analysis of the non-nitrogenous organic acids present in raw cane juice, clarified juice and molasses has been carried out by adapting the procedure of Marvel and Rands. This method involves the separation of organic acids by partition chromatography on a column of silicic acid. The silicic acid column was first standardised as customary, by conducting the separation of a known mixture of eight organic acids, namely, fumaric, lactic, succinic, malonic, aconitic, malic, citric, tartaric and oxalic acids. To carry out the analysis of organic acids occurring in raw juice, clarified juice and molasses, they were first obtained as mixtures of sodium salts by ion exchange resin (Amberlite IRA-400) treatment. The acids thus obtained were resolved on silicic acid column and the individual components were identified by their characteristic peak effluent volumes. Thus raw cane juice was found to contain mesaconic, fumaric, lactic, succinic, maleic, aconitic, glycollic, malic, citric, tartaric and oxalic acids. All these acids were also found to be present in clarified juice and molasses. In addition to them, the existence of two other acids namely lactic and malonic acids in clarified juice and molasses was also noted. These two acids were identified from their peak effluent volumes and also from paper chromatographic analysis with known reference sample. From the quantitative estimation results it appears that there are some organic acids whose proportions gradually decreases during processing of cane juice *e.g.*, mesaconic, fumaric, succinic and aconitic acids. On the other hand the proportions of lactic, malonic and glycollic acids gradually increase during the same treatment. The behaviour of other organic acids was found to be irregular.

The above results indicate that lactic and malonic acids are formed when cane juice is subjected to the process of clarification and boiling. The production of lactic acid as an artifact is already known. Simultaneous formation of malonic acid is however a new finding and has not been reported before. The mechanism by which these two acids generated during the processing of cane juice has been discussed. It seems that during the clarification of raw sugar cane juice, lime treatment results in the formation of glyceraldehyde and glucic acid from the reducing sugars. Glyceraldehyde upon saccharinic acid type rearrangement forms lactic acid while glucic acid undergoes internal disproportionation reaction giving rise to half aldehyde of malonic acid which is finally oxidised to malonic acid.

SHORT NOTES ON ARGYROPLOCE EROTIAS MEYR. (LEPIDOPTERA-EUCOSMIDAE)

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The *Argyroploce erotias* Meyr, the litchi leaf roller is widely distributed in plains and is a pest of litchi. Originally the pest has been recorded on mangoin Bombay and Pusa by Fletcher (1916 & 17). It is a sporadic pest, but when it occurs in large numbers a considerable damage is caused to the plants. At Kanpur it has been observed attacking the litchi plants also. Very little information is available on its biology in India and other countries, hence this piece of work was undertaken.

Mass collection of the larvae was made from litchi orchards, Govt. Agricultural College, Kanpur and these larvae were kept in petridishes and jars (10 lbs) with litchi twigs. The moths were fed upon weak glucose solution (5-10%) soaked in cotton wool and placed inside the jars.

LIFE HISTORY

The female moth lays 60-156 eggs singly on the tender leaves of litchi. The eggs are round, flat and pale white measuring about 0·32 mm. in diameter. They remain glued to the leaves of the host plant. The eggs hatch in 2 to 7 days. The newly hatched larvae are creamy white in colour with greyish-black head. The thoracic and abdominal legs are present and it measures about 2·5 mm. in length. After a day or two they join the two edges of the tender leaf and feed inside the fold. Sometimes the larvae have been observed suspended in the air by white silken thread spun by themselves.

The full grown larva (Fig. 1) measures about 15·5 mm. in length and 2 mm. in width, slightly flattened and tapering towards the extremities. The larva is uniform green in colour. All the body segments are clearly seen. Head is flattened, greyish-yellow in colour and smaller than prothorax, which is covered by a black shield. All the abdominal legs are present. The larva rolls the tender leaves of the plant by means of a white silken thread from edge inward, living inside and feeds upon the rolled leaf. As the time of pupation approaches it changes its colour from green to greyish-black and pupates among the silken cocoon, inside the rolled leaf, with a prepupal stage of 1-3 days. The larval period varies from 12-57 days, depending upon the season.

The pupa (Fig. 2) measures about 8×2·5 mm. The colour varies from yellowish-brown to light brown with greenish tinge. After 7-23 days, moth emerges from the pupa. At emergence it secretes a bluish-green fluid. The whole process of emergence takes 6 to 8 minutes. The adult moth measures 18 × 8 mm. The fore wings are light black in colour and hind wings smoky with shining small patch in the middle of the costal region. Both pairs of wings are fringed with hairs. The abdomen in female is dark brown in colour and tapers posteriorly. The abdomen in male is slender, narrow in the middle and broad at ends. The adult moth (Fig. 3) is nocturnal in habit and lives for about 10 days when fed on glucose solution, under laboratory conditions.

The pest is found throughout the year, in all stages of development. But maximum activity has been observed from July to November, less in summer and minimum in winter. 5-7 overlapping generations have been noticed in a year.

DAMAGE

The damage is caused by the caterpillar which rolls the tender leaves of the litchi plant by means of white silken threads. They live inside and eat away the leaf. Sometimes the rolled leaf is covered by another fresh leaf or they join two leaves into rolls. It has been observed that the fresh mango leaves are also preferred by the larvae. In few cases it has also been noticed that the larvae of the Ist and IInd stage bore through the midrib and petiole of the litchi and mango leaves. The maximum damage is done in the months of October to middle of November (about 32% plants were affected).

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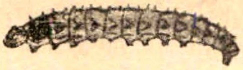

Fig. 1. Larva

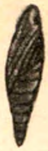

Fig. 2. Pupa

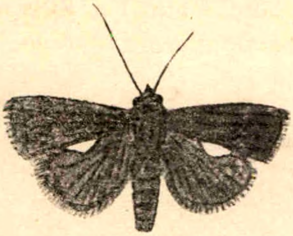

Fig. 3. Adult

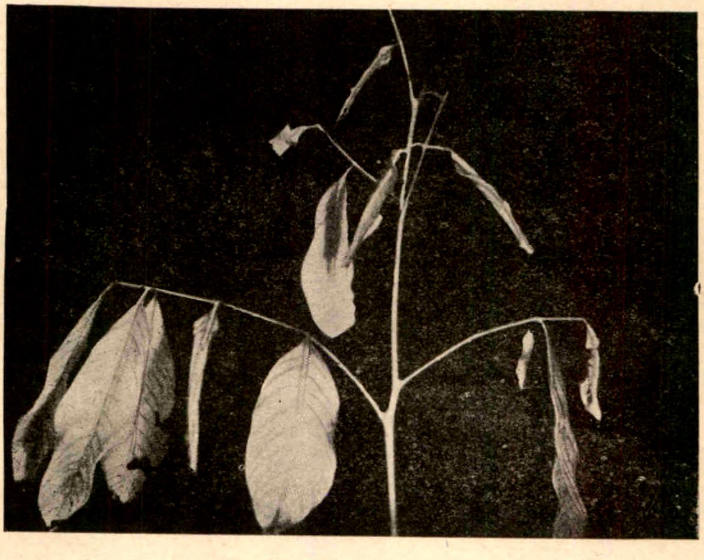

Fig. 4. Damaged Litchi Twig.

THE ANOMALIES IN THE FORCEPS OF MALE *FORCIPULA QUADRISPINOSA* DOHRN AND MALE *NALA LIVIDIPES* DUFOUR (DERMAPTERA)

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Earlier taxonomists who laid special emphasis on morphological structures for the separation of species, extensively utilized the differences in size, shape, structure and number of teeth on the inner side of the forceps for distinguishing one species from another in Dermaptera. Recently, however, workers like Van Heerdt (1953) and Ramamurthi (1961) struck a note of caution on the utility of such intraspecific variations, particularly in the forceps of male earwigs. Van Heerdt (1953), on the basis of biometrical analysis, established that the intraspecific variation in the forceps of male common earwig, *Forficula auricularia* L., has no genetic basis and suggested that such differences occur due to the environmental factors. Later Ramamurthi (1961) described such variations in the shape and size of the forceps and pygidium of male *Diplatys gladiator* Burr, male *Auchenomus hincksi* Ramamurthi and male *Forcipula quadrispinosa* Dohrn due to differences in ecological conditions.

While studying the collections of *Forcipula quadrispinosa* Dohrn and *Nala lividipes* Dufour made from different parts of the country, some very interesting anomalous forceps were observed. Not only forceps of males in these two species are greatly variable in size and shape, asymmetrical growth of two arms of the forceps were found to occur not very infrequently. A reference to figures 1-4 reveals that in male *Forcipula quadrispinosa* Dohrn both left and right arms of the forceps show abnormal growth. In figure 1, the right arm of the forceps, having its origin slightly above the origin of the normal left one, and being more than one-half of its length, is smooth, curved inward and appearing almost like a hook. In figure 2, the left arm of the forceps is smooth, nearly straight and about three-fourth in length in comparison to the normal right one. In figure 3, the left arm is somewhat straight, smooth and smaller than the normal size of forceps, while the right arm is very small and recurved over the last abdominal segment. Lastly in figure 4, both the arms of the forceps are well-developed and similar in structure but the right arm is slightly smaller than the left and its large tooth is slightly above the level of its counterpart in the left one.

Similarly, a reference to figures 5 and 6 reveals that in male *Nala lividipes* Dufour the right arm of the forceps shows abnormal growth. In figure 5, the right arm is very small, rough in outline, without tooth and less than half as long as the normal left. Figure 6 shows a similar case as in figure 4 of male *Forcipula quadrispinosa* Dohrn. In this figure also both the right and left arms of the forceps are well-developed and similar but the right one is slightly smaller and consequently the two teeth do not lie at the same level in both the arms.

It is conjectured that asymmetrical growth of the two arms of the forceps may be consequent to damage or injury caused to one of the arms and this asymmetrical nature can be hardly relied upon as character of any taxonomic importance.

ACKNOWLEDGMENTS

My sincere thanks are due to Dr. H. N. Baijal, Zoology Department, for guidance and critical suggestions. I am also grateful to the Head of the Zoology Department and Dr. M. Ray, D.Sc., F.N.I., Principal, Agra college, Agra, for facilities and encouragement.

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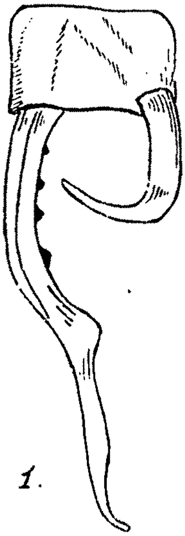

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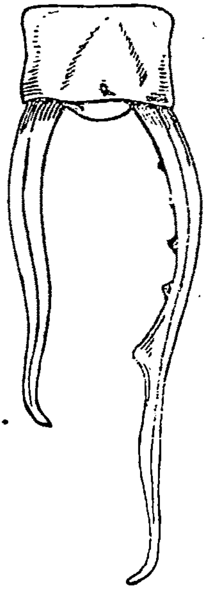

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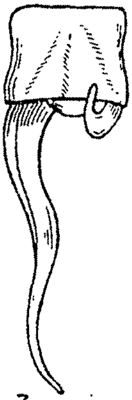

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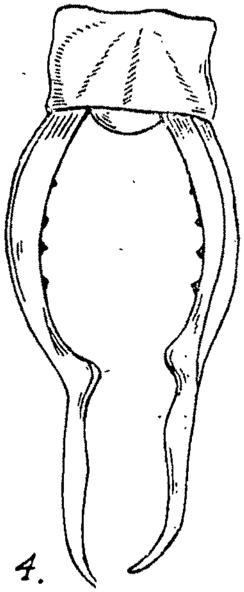

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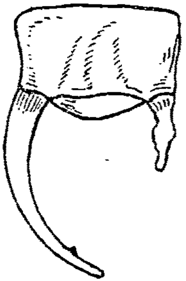

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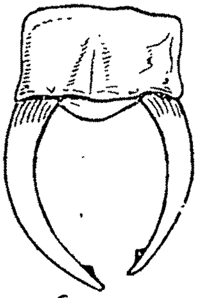

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Figs. 1-4. *Forcipula quadrispinosa* Dohrn The anomalous growth in the forceps of male
Figs. 5-6 *Nala lividipes* Dufour.

STUDIES ON INDIAN AGROMYZIDAE (DIPTERA) PART—II DESCRIPTION OF TWO NEW SPECIES AND RECORD OF FOUR KNOWN SPECIES OF GENUS *MELANAGROMYZA* HENDEL.*

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This paper contains descriptions of two new species *viz.*, *Melanagromyza indica* sp. nov., *Melanagromyza surdasi* sp. nov. and record of four known species of genus *Melanagromyza* from India. The type specimens will be deposited in the National Collections at Zoological Survey of India, Calcutta.

I offer my grateful thanks to Dr. T. Singh, Professor of Zoology and Entomology for guidance and for facilities for work. Also I thank Dr. Santokh Singh and Dr. J. L. Nayar for help in various ways during the preparation of this paper.

ABBREVIATIONS

fo—Fronto-orbital bristle (s); ors—Upper fronto-orbital bristle (s); ori—Lower fronto-orbital bristle (s); dc—Dorsocentral bristle (s); acr—Acrostichal hairs; ia—Intra-alar; sa—Supra-alar; pa—Post-alar bristle (s); np—Notopleural bristle (s); ps—Pre-sutural bristle (s).

1. *Melanagromyza alternata* Spencer

1961. *Melanagromyza alternata* Spencer, *Trans. R. ent. Soc. Lond.*, 113(4) : 67.

I refer to this species 3 ♂ ♂ on pin labelled "Coimbatore, A. S. Rao, 3. vii. 1951, maggot mining leaves of *Pongamia* sp."

Distribution.—India : Coimbatore; Formosa : Paroe, Northern Paiwan District.

The species was originally described by Spencer (1961) from Formosa. This is the first record of the species from within India and the host plant too has not been recorded earlier.

2. *Melanagromyza atomella* (Malloch)

1914. *Agromyza atomella* Malloch, *Ann. hist. nat. Mus. Hung.*, 12 : 331.

1941. *Melanagromyza atomella* (Malloch) Hennig, *Ent. Beihefte*, 8 : 1-239.

1961. *Melanagromyza atomella* (Malloch) Spencer, *Trans. R. ent. Soc. Lond.*, 113(4) : 67-69.

1962. *Melanagromyza atomella* (Malloch) Spencer, *Pacific Insects*, 4(3) : 669.

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* Contribution No. 119 from the School of Entomology, St. John's College, Agra.

I have before me 10 ♀ ♀ and 9 ♂ ♂ specimens labelled "Botanical Garden, St. John's College, Agra, coll. Santosh K. Tandon, 12. ix. 1962; maggot mining leaves of *Quisqualis indica* Blanco," and "Kottayam, coll. Santosh K. Tandon, 25.i. 1962; maggot mining leaves of *Quisqualis indica Blanco.*"

Distribution.—India : Agra, Kottayam (S. India); Formosa; Pilam, Takao, Tainan; Ceylon : Colombo; Philippine : Luzon, Los Banos.

The species was originally described by Malloch (1914). This species is being recorded here for the first time from within India.

3. *Melanagromyza chalcosoma* Spencer

1959. *Melanagromyza chalcosoma* Spencer, *Trans. R. ent. Soc. Lond.*, 111(10) : 263.

I refer to this species a series of specimens from N.P.C. Collections at I.A.R.I., New Delhi, labelled "5.iii.1928, from stem of *Vernonia Cineria*; Pusa, Rangi coll.", and "3.iv.1928, in bored hollow stem of *Ramex maritimas*; Pusa, Rangi coll."

Distribution.—India : Pusa; Nyasaland : Namiwawa.

The species was first described by Spencer (1959) from Africa. This is the first record of the species from within the Oriental faunal limits.

4. *Melanagromyza indica* sp. nov.

Head.—(figs. 1 and 2) Frons slightly wider than eye (1·1 : 1), more han twice as long as wide, sides almost parallel. Face almost vertical with extremely narrow carina; lunule whitish, large, broad and deeply convex dorsally, sparsely pubescent; parafrontals extremely narrow, slightly bulged out and about one-tenth as wide as the frons; sides almost parallel. Ocellar triangle with dorsal side sub-equal to the width of the frontalia; lateral sides slightly convex and gradually converging anteriorly to an angle, slightly above the base of *ors*; ocelli ochraceous; interocellar surface glabrous. Fronto-orbitals four pairs, two *ors* reclinate and the two *ori* proclinate; the upper most *ors* slightly longer than the *ori*. Frontalia not projecting above eyes; cheeks broad, deepest in centre, below eye about one-fifth height of eye; marginal setae and oral vibrissae prominent. Eyes pilose in male. Antennal grooves deep, somewhat divergent, located below the mid-level of the eye; second antennal segment with prominent bristles; third segment rounded apically; arista long; conspicuously plumose, about two and a half times as long as the antenna and about half the vertical height of the eye.

Thorax.—(fig. 3) Mesonotum with two pairs of strong *dc* posterior to transverse suture; the first *dc* about twice the length of the second *dc*; six regular rows of *acr* extending posteriorly up to the level of the second *dc*; *ia* one, two-thirds the length of the first *dc*; *sa* one, strong; pteropleurals numerous; *pa* one, almost equal to the *sa*; *np* two, strong, anterior being slightly shorter than the posterior; humeral small; *ps* one. Mesopleura with two prominent setulae directed backwards; sternopleurals two, directed ventrally.

Wing.—(fig. 4) Costa ending at M_{1+2}; second, third and fourth costal segments as 4 : 1·1 : 1; wing apex between termination of R_{4+5}, and M_{1+2}, nearer to R_{4+5}; R_{4+5} and M_{1+2} almost parallel but slightly diverging apically; last section of vein M_{1+2} about four times as long as the penultimate section; r-m slightly distal to the termination of R_1 and just beyond the middle of discal cell; ultimate segment of M_{3+4} in ratio 1 : 1·9 with the penultimate.

Legs.—Mid-tibiae without bristles.

Abdomen.—Abdomen broadly ovate, each tergite covered with numerous setae; sixth tergite longest, convex posteriorly and covered with prominent marginal setae.

Colour.—Head matt; parafrontals dark; frontalia and ocellar triangle shining; lunule white; cheeks dull-black; antenna and arista black; eyes dark-brown. Mesonotum and pleurae with shining greenish tinge, scutellum more coppery; abdomen some-what shining, blackish-green. Wings hyaline; squammae and fringe white, margins only slightly contrasting, veins brown; halteres black.

Measurements :

	Body length	Wing length
♂	4·8 mm	3·2 mm

Holotype.—Male labelled "Sikandra (Agra, India), 4.iii.1962, coll. Santosh K. Tandon, on grass." In the collections of the School of Entomology, St. John's College, Agra.

The species resembles *Melanagromyza lasiops* (Malloch) from Formosa but can easily be separated by the absence of postero-dorsal bristles on the mid-tibiae and the jowls being broad.

Distribution.—India : Agra.

5. *Melanagromyza metallica* (Thomson)

1869. *Agromyza metallica* Thomson, *Eugenies Resa Diptera*, Stockholm, p.609.
1912. *Agromyza similis* Lamb, *Trans. Linn. Soc. Lond.*, 15 : 344-7.
1923. *Agromyza lambi* Hendel, *Konowia*, 2 : 142-5, (nom. nov. for *similis* Lamb), syn. nov.
1925. *Melanagromyza similis* (Lamb) Bezzi and Lamb, *Trans. ent. Soc. Lond.*, pp. 537-73.
1959. *Melanagromyza metallica* (Thomson), Spencer, *Trans. R. ent. Soc. Lond.*, 111(10) : 278.
1961. *Melanagromyza metallica* (Thomson) Spencer, *Trans. R. ent. Soc. Lond.*, 113(4) : 74.
1962. *Melanagromyza metallica* (Thomson) Spencer, *Pacific Insects*, 4(3) : 672.

I have before me 13 ♂ ♂ and 19 ♀ ♀ specimens labelled "Kumli (Kerala), from flower heads of *Ageratum* sp., 27.i.1963; coll. Santosh K. Tandon and Ipe M. Ipe."

Distribution.—India : Kumli (Kerala); Europe; Indonesia; Philippines; South Africa; Congo.

The species was originally described by Thomson (1869) from Europe and is being reported here for the first time from within India.

6. *Melanagromyza surdasi* sp. nov.

Head.—(Figs. 5 and 6) Frons slightly wider than width of eye (0·22 : 0·20 mm); twice as long as wide, sides almost parallel but slightly diverging dorsally; lunule whitish, sparsely pubescent; parafrontals conspicuously bulged out and about one-fourth as wide as the frontalia; sides parallel. Ocellar triangle, with dorsal side sub-equal to the width of the frontalia, the ventral angle less than 90° and rounded, extending up to the level of the upper orbital bristles. Fronto-orbitals four pairs, two *ors* reclinate and the two *ori.* proclinate, the latter slightly longer than the former. In profile the parafrontals slightly visible above the eye. Cheeks extremely narrow, about one-tenth the vertical height of the eye. Face almost vertical with carina very narrow; frontalia not projecting above the eyes in profile. Eyes almost bare. Antennal bases non-contiguous, third antennal segment shorter than broad, rounded apically with white microscopic pubescence; arista about one and a half times as long as the antenna, swollen basally and bare. Strong three pairs of oral vibrissae, accompanying with minute pubescence, peristomal setae almost as strong as vibrissae.

Thorax.—(Fig. 7) Mesonotum with two long *dc* posterior to transverse suture; first *dc* slightly longer than the second, and far below the level of the *sa*; regular six rows of *acr* extending posteriorly up to the level of second *dc*; *ia* one strong; *sa* one strong, accompanying with relatively prominent setulae; *pa* one strong; humeral one with minute setulae; presutural one, a little more than the length of second *dc.* Mesopleura with about four to six setulae, directed dorsally, sternopleural bristle strong and directed backwards.

Wing.—(Fig. 8) Costa ending at M_{1+2}, second, third and fourth costal sections as 5·2 : 1 : 1·2; wing apex between termination of R_{4+5} and M_{1+2}; R_{4+5} and M_{1+2} slightly curved and almost parallel but gradually diverging apically; r-m slightly proximal to the termination of R_1 and little beyond the mid-point of discal cell; ultimate segment of M_{3+4} in ratio 15 : 16 with the penultimate.

Legs.—Mid-tibiae with strong tibial spur but no postero-dorsal bristle.

Abdomen.—Oval, each tergite sparsely covered with short setae; sixth greitte convex posteriorly with prominent marginal setae.

Colour.—Head black; parafrontals and ocellar triangle shining dark-brown; lunule white; cheeks dark-brown; antenna dark-brown, arista dark; proboscis dirty-yellow; eyes dark-brown with black patches. Mesonotum and scutellum black; pleurae black; wings hyaline, base pale, calypters with fringe white; halteres black; legs dark-brown, tibiae and tarsomeres black. Abdomen shining-black.

Measurements.—

Body length	Wing length
2·0 mm	1·9 mm

Puparium.—White.

Holotype.—Male labelled "Keetham (Agra, India), 12.viii.1962, coll. Santosh K. Tandon; maggot mining leaves of *Dema extensa.*" In the collections of the School of Entomology, St. John's College, Agra. One male paratype with the same data.

This species comes nearer to *Melanagromyza alternata* Spencer, but can easily be separated by its smaller size, ocellar triangle extending up to the level of upper orbitals and in the ratio of vein M_{3+4}.

Distribution.—India : Surdas Forest surrounding the Keetham lake, Agra District, 13 miles on the Agra-Mathura Road.

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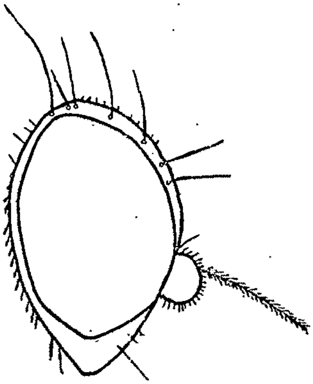

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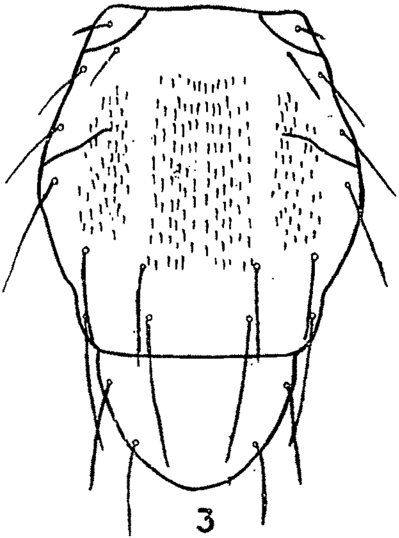

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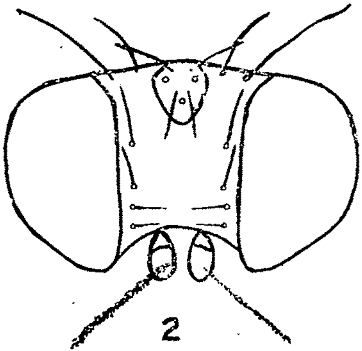

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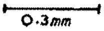

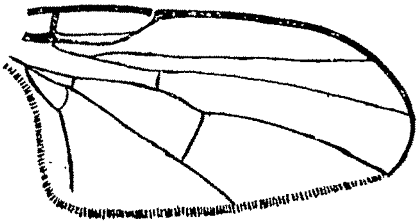

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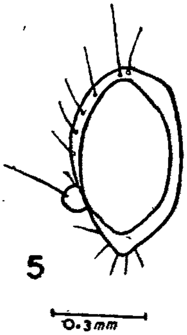

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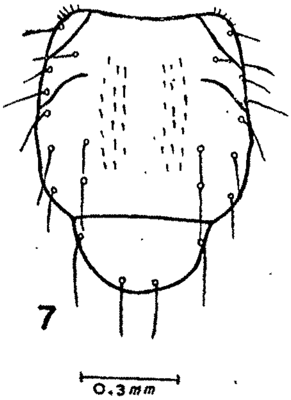

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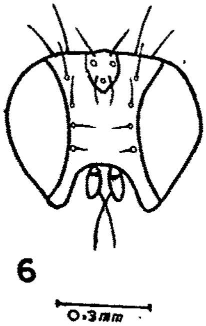

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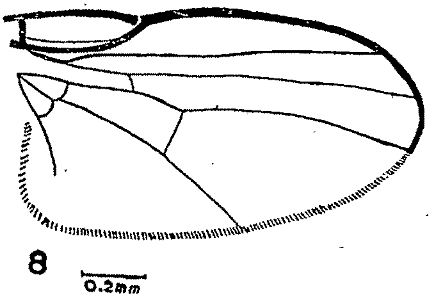

8

SYNTHESIS OF 1: 2: 3-BENZOTRIAZOLES

SOME 2-(3'-CHLORO-4'-METHYL)-;2-(4'-BROMO)-AND 2-(2' : 3'-DICHLORO)-PHENYL-1 : 2 : 3-BENZOTRIAZOLES.

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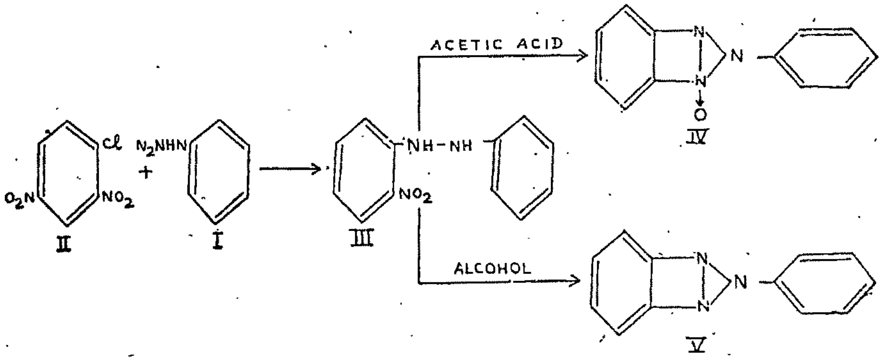
2-phenyl-1:2:3-benzotriazoles were obtained by the condensation of phenylhydrazines (I) with reactive halogenonitrobenzenes (II), having a nitro group in their ortho position[1-5]. The first product of the condensation is a hydrazobenzene derivative[1-3,6](III). In acetic acid solution the hydrazobenzene derivative cyclises to form 2-phenyl-1:2:3-benzotriazole-1-oxide[7,8] (IV). However, if the reaction is carried out in alcoholic solution the 1 oxide first formed gets reduced to 2-phenyl-1:2:3-benzotriazole[1,2,7-9] (V).



During the present investigations a few 2-phenyl-1:2:3-benzotriazoles have been prepared by the condensation of 1-chloro-2:4-dinitro-; 1-chloro-2:4:6-trinitro-; 1:3-dichloro-4:6-dinitro-; 1:4-dichloro-2-6-dinitro-; 1:2-dichloro-4:6-dinitro-; 1-chloro-4:6-dinitro-3-methyl-; 1-chloro-2:6-dinitro-4-methyl-; 1-chloro-2:4:6-trinitro-3-methyl-; 1:2:5-trichloro-4:6-dinitro- and 2:5-dichloro-1-bromo-4:6-dinitro benzene with 2:3-dichloro- (Table 1), 3-chloro-4-methyl-(Table 2), and 4-bromo phenyl hydrazines (Table 3) respectively in alcoholic solution. No attempts have been made to isolate the intermediate 1-oxides.

Out of the reactive halogenonitrobenzenes investigated, 1-chloro-2:4:6-trinitro-3-methyl-; 1:2:5-trichloro-4:6-dinitro- and 2:5-dichloro-1-bromo-4:6-dinitro benzene can react in more than one way. But it is noteworthy that in all these cases only one compound could be isolated from the reaction product.

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By the condensation of 1:2:5-trichloro-4:6-dinitro benzene with p-bromophenylhydrazine three isomeric compounds, 2-(4′-bromo) phenyl-6:7-dichloro-4-nitro-; 2-(4′-bromo) phenyl-4:7-dichloro-6-nitro- and 2-(4′-bromo) phenyl-5:6-dichloro-4-nitro-1:2:3-benzotriazoles could possibly result. But under the conditions employed only one compound could, however, be isolated which is found to be identical with the product obtained by the condensation of p-bromophenylhydrazine with 2:5-dichloro-1-bromo-4:6-dinitrobenzene. It, therefore, must be 4:7-dichloro-6-nitro-2- (4′-bromo-) phenyl-1:2:3-benzotriazole.

Similarly 1:2:5-trichloro-(or 2:5-dichloro-1-bromo-)-4:6-dinitro-benzene gave 4:7-dichloro-6-nitro-2-(3′-chloro-4′-methyl-) phenyl and 4:7-dichloro-6-nitro-2-(2′:3′-dichloro-) phenyl-1:2:3-benzotriazoles when condensed with 3-chloro-4-methyl- and 2:3-dichloro phenylhydrazines respectively.

In the formation of 1:2:3-benzotriazoles and other similar heterocyclic compounds from reactive halogenonitrotoluenes it has been observed that the nitro group in ortho position to the methyl group takes part in the cyclisation[1,2]. Thus 1-chloro-3-methyl-2:4:6-trinitrobenzene gave 2-(4′-bromo) phenyl-; 2-(3′chloro-4′-methyl) phenyl- and 2-(2′-3′-dichloro) phenyl-4:6-dinitro-7-methyl-1:2:3-benzotriazoles when condensed with 4-bromo-; 3-chloro-4-methyl- and 2:3-dichloro phenylhydrazines respectively.

EXPERIMENTAL

Preparation of substituted phenylhydrazines—2:3-dichloro-; 3-chloro-4-methyl- and 4-bromo phenylhydrazines have been prepared from the corresponding anilines by diazotisation and reduction in usual way.

Preparation of 1:2:3-benzotriazoles—2-(4′-bromo) phenyl, 2-(3′-chloro-4′-methyl) phenyl and 2-(2′:3′-dichloro) phenyl-1:2:3-benzotriazoles have been obtained by the condensation of halogenonitrobenzenes with 4-bromo-, 3-chloro-4-methyl- and 2:3-dichlorophenyl hydrazines respectively according to the method of Joshi and Gupta.[1] The melting points, yields, other characteristics and analytical data of these compounds are described in Tables 1, 2 and 3.

ACKNOWLEDGEMENT

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TABLE 1

2-(2′-3′-dichloro) phenyl-R-1:2:3-benzotriazoles.

S. No.	Halogenonitrobenzene used	R	M. P. °C	Colour	Formula	Found	Reqd.
1.	1-chloro-2:4-dinitro-	6-nitro-	190	Dark Yellow	$C_{12}H_6N_4O_2Cl_2$	Cl, 22·91%	22·98
2.	1-chloro-2:4:6-trinitro-	4:6-dinitro-	160	Dark Brown	$C_{12}H_5N_5O_4Cl_2$	Cl, 20·15	20·06
3.	1:3-dichloro-4:6-dinitro-	5-chloro-6-nitro-	193	Sepia	$C_{12}H_5N_4O_2Cl_3$	Cl, 30·98	31·00
4.	1:4-dichloro-2:6-dinitro-	4-nitro-6-chloro-	214	Buff	$C_{12}H_5N_4O_2Cl_3$	Cl, 31·19	31·00
5.	1:2-dichloro-4:6-dinitro-	4-chloro-6-nitro-	218	Brick Red	$C_{12}H_5N_4O_2Cl_3$	Cl, 30·82	31·00
6.	1-Chloro-4:6-dinitro-3-methyl-	5-methyl-6-nitro-	170	Yellow	$C_{13}H_8N_4O_2Cl_2$	Cl, 22·12	21·98
7.	1-chloro-2:6-dinitro-4-methyl-	4-nitro-6-methyl-	150	Dark Sepia	$C_{13}H_8N_4O_2Cl_2$	Cl, 21·88	21·98
8.	1-chloro-2:4:6-trinitro-3-methyl-	4:6-dinitro-7-methyl-	above 300	Black	$C_{13}H_7N_5O_4Cl_2$	Cl, 19·03	19·32
9.	1:2:5-trichloro-4:6-dinitro-	4:7-dichloro-6-nitro-	203	Chocolate	$C_{12}H_4N_4O_2Cl_4$	Cl, 37·39	37·57
10.	2:5-dichloro-1-bromo-4:6-dinitro-	4:7-dichloro-6-nitro-	203	Chocolate	$C_{12}H_4N_4O_2Cl_4$	Cl, 37·25	37·57

N. B. All melting points are uncorrected.

Table 2

2-(3′-chloro-4′-methyl) phenyl-R-1:2:3-benzotriazoles.

S.No.*	M.P. °C	Colour	Formula	Found	Reqd.
1.	185	Light Yellow	$C_{13}H_9N_4O_2Cl$	Cl,12·39	12·30
2.	160	Tan	$C_{13}H_8N_5O_4Cl$	Cl,10·66	10·65
3.	174	Yellow	$C_{13}H_8N_4O_2Cl_2$	Cl,21·92	21·96
4.	158	Sepia	$C_{13}H_8N_4O_2Cl_2$	Cl,21·98	21·96
5.	210	Brown	$C_{13}H_8N_4O_2Cl_2$	Cl,21·99	21·96
6.	135	Bright Yellow	$C_{14}H_{11}N_4O_2Cl$	Cl,11·78	11·74
7.	196	Brown	$C_{14}H_{11}N_4O_2Cl$	Cl,11·70	11·74
8.	100	Chocolate	$C_{14}H_{10}N_5O_4Cl$	Cl,10·26	10·22
9.	189	Brown	$C_{13}H_7N_4O_2Cl_3$	Cl,29·82	29·79
10.	189	Brown	$C_{13}H_7N_4O_2Cl_3$	Cl,29·71	29·79

Table 3

2-(4′-bromo) phenyl-R-1:2:3-benzotriazoles.

S.No.*	M.P. °C	Colour	Formula	Found	Reqd.
1.	193	Brown	$C_{12}H_7N_4O_2Br$.	Br,24·98	25·08
2.	231	Dark Brown	$C_{12}H_6N_5O_4Br$.	Br,22·01	21·98
3.	191	Brown	$C_{12}H_6N_4O_2Cl\,Br$.	Cl+Br,32·72	32·68
4.	219	Brown	$C_{12}H_6N_4O_2Cl\,Br$.	Cl+Br,32·73	32·68
5.	180	Brown	$C_{12}H_6N_4O_2Cl\,Br$.	Cl+Br,32·81	32·68
6.	225	Grey	$C_{13}H_9N_4O_2Br$.	Br,24·16	24·02
7.	190	Brown	$C_{13}H_9N_4O_2Br$.	Br,24·19	24·02
8.	160	Yellow	$C_{13}H_8N_5O_4Br$.	Br,20·97	21·16
9.	178	Faun	$C_{12}H_5N_4O_2Cl_2Br$.	Cl+Br,39·12	38·92
10.	178	Faun	$C_{12}H_5N_4O_2Cl_2Br$.	Cl+Br,38·69	38·92

*Number of halogenonitrobenzene used and R is the same as in Table 1.

SELF-INCOMPATIBILITY IN PSIDIUM MOLLE BERTOL

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Self-incompatibility is one of the several outbreeding devices. It could be defined as a mechanism developed in certain bisexual flowers by which self-fertilized flowers fail to develop any seed. The egg as well as the pollen grains in these cases, are however, perfectly fertile. Occurence of self-incompatibility has been reported in at least 71 different families of flowering plants (Brewbaker and Majumdar, 1961). Fryxell (1957), who reviewed 600 genera for incompatibility found 250 genera to be self-incompatible. Non-setting of seeds due to self-incompatibility has also been recorded in some of the *P. guajava* varieties (Balsubramanyam and Rangaswami, 1959; Seth, 1959). While doing interspecific hybridization in *Psidium* species, it was observed that most of the flowers of *P. molle* dropped off within four to five days of their opening. If these flowers were bagged in bud condition, drop was 100 per cent. All the plants of *P. molle* growing at the Institute were raised vegetatively from a single plant and hence they belonged to one and the same variety. Pollen grains of these plants were fertile and germinated well in 15 per cent sucrose (Seth, 1961). The problem of non-setting in *P. molle* was therefore, studied to find out its real causes and suggest methods to overcome this defect.

MATERIAL AND METHODS

Experiments were carried out (during rainy season bloom of 1958 and 1959) on three healthy and uniform plants of *P. molle* which were about eight years old. These studies were conducted under two heads—(a) Experiments devised for finding the causes of non-setting and (b) experiments to overcome this defect.

Under the first part of study, three treatments *viz.*, (i) self-pollination, (ii) open-pollination and (iii) cross-pollination with *P. guajava* were tried. Ten flowers were used in each treatment. Under self-pollination treatment, ten extra flowers were selfed for observing pollen tube growth in the style and fertilization.

Styles used for pollen tube growth studies were fixed in aceto-alcohol hydrolysed in 80 per cent acetic acid at 60°C for an hour or two and stained in safranin-aniline blue according to Diome and Spicer's (1958) technique. Permanent *slides* were prepared in normal butyl alcohol series (Bhaduri and Ghosh, 1954). Serial sections were cut of ovaries, four, six and eight days after pollination to observe fertilization. Safranin-fast green was used for staining the sections (Jhonsen, 1940).

(b) To evercome non-setting following treatments were tried on twelve flowers per tree under each treatment:—

(i) Alpha-naphthalene-acetic acid, beta-indolebutyric acid and gibberellic acid in concentrations of 50, 100 and 150 ppm were sprayed soon after pollinating the flowers. A mixture containing 100 ppm gibberellic acid and 100 ppm boric acid was also sprayed during 1960.

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(ii) Lanolin paste containing one of the three plant regulators mentioned above in concentrations of 0·5, 1·0 and 1·5 per cent was applied on the side of the ovary at the time of pollination.

(iii) Ovary with its top trimmed close to the ovules was subjected to the following treatment :—

(A) Pollen grains were dusted on the cut surface of the ovary following an application of 15 per cent sucrose in 0·5 per cent agar solution, (B) culture media containing germinated pollen grains applied on the trimmed ovaries, (C) lanolin paste of 1·0 per cent indolebutyric acid or gibberellic acid applied to the ovaries treated like (A) and (B). Ten trimmed ovaries were left untreated to serve as control. After these treatments ovaries were covered with polyethylene bags so as to provide enough humidity for pollen germination.

Two ovaries from each of the above mentioned treatments were fixed in formalin-acetic acid-alcohol (70%) after a week to observe ovule development.

OBSERVATIONS

The results showing fruit-setting and seed formation by different pollination treatments are given in Table 1.

TABLE 1

Fruit and seed-setting in P. molle by different methods of pollinations.

Pollination treatment	Year	No. of flowers pollinated	No. of fruits set.	Percentage of fruit setting	Average No. of seeds per fruit
Self pollination	1958	30	...	...	...
	1959	,,	...	...	...
Natural pollination	1958	,,	4	13·3	8·4
	1959	,,	6	20·0	6·0
Cross pollination	1958	,,	18	60·0	14·7
	1959	,,	20	66·6	8·7

It is clear from Table 1 that no fruit-set took place under self-pollination whereas in open-pollination, 13·3 to 20·0 per cent flowers developed mature fruits having 6 to 8·4 seeds per fruit. In the case of flowers cross-pollinated with *P. guajava*, fruit-set as well as presence of normal seeds in each fruit was very high (60·0 to 66·6% fruit-setting with 8·7 to 14·7 seeds per fruit). Thus, pollination treatment showed that *P. molle* flowers failed to set fruits and seeds on self-pollination, but normal fruits with viable seeds were produced on cross-pollination and open-pollination. This indicates that the ovules of *P. molle* were quite normal, but fertilization was possible only on cross-pollination. The fruit and seed-setting in open pollinated flowers was apparently due to normal cross-pollination.

Stigmas and styles of self-pollinated flowers showed a large number of germinated pollen grains (Fig. 1), and pollen tubes were found to penetrate the style to some distance, but later on their growth was arrested. Tips of several pollen tubes swelled and burst inside the style. Sections of ovaries showed unfertilized embryo sacs even seven to eight days after selfing and in several of them degeneration had set in (Fig. 2). It was thus obvious that both pollen grains and embryo sacs of *P. molle* were functional but the failure of self-fertilization was due to inhibition of pollen tube in the style.

The results of the treatments effective for overcoming the self-incompatibility in *P. molle* have been summarized in Table 2.

TABLE 2

Effect of various treatments tried for overcoming self-incompatibility.

Treatments	Year	Fruit setting percentage	Average fruit height in cm.	Average max. diameter of fruits in cm.	Average fruit weight in gm.	Percentage of seeded fruits	Average No. of seeds per fruit	Percentage of germinated seeds
Gibberellic acid 50 ppm	1958	...	...	...	...	...	...	...
	1959	...	...	...	...	...	...	...
100 ppm	1958	43·3	2·5	2·2	6·0	46·1	2·0	16·6
	1959	56·6	2·6	2·4	6·7	35·2	2·5	20·0
150 ppm	1958	66·6	2·8	2·5	6·7	23·8	1·5	10·3
	1959	50·0	2·7	2·4	6·6	26·2	2·0	...
Gibberellic acid ppm+boric acid 100 ppm.	1960	63·3	1·9	1·8	4·1	36·8	3·1	13·6
Untreated trimmed ovaries	1958	...	...	...	...	...	...	...
	1959	...	...	...	...	...	...	...
Culture+pollen on trimmed ovaries	1958	20·0	1·8	1·2	3·0	...	...	...
	1959	13·3	1·9	1·4	3·5	...	...	...
Culture+germinated pollen on trimmed ovareis	1958	26·6	1·8	1·4	4·2	...	...	...
	1959	18·3	1·7	1·1	3·0	...	...	...
Culture+pollen +I. B. A. 1% on trimmed ovaries	1958	26·6	2·0	1·4	3·8	...	...	...
	1959	36·6	2·1	1·3	4·0	...	...	...
Culture+germinated pollen+I.B.A. 1% on trimmed ovaries	1958	26·6	1·8	1·2	3·0	...	...	...
	1959	30·0	1·9	1·4	3·5	...	...	...

It was observed that plant regulators, applied through sprays or in lanolin paste, only delayed flower shedding for some days. Setting of fruits and formation of seeds took place only in flowers sprayed with gibberellic acid. Flowers sprayed with 50 or 100 ppm indole butyric acid did not drop for eight to ten days but their ovaries did not grow at all. Naphthalene acetic acid sprays were toxic to flowers at 100 ppm and lower concentrations had no effect. Among all the plant regulators tried gibberellic acid sprays at 100 and 150 ppm were most effective. The percentage of fruit-set was high in both the concentrations. Normal viable seeds were more abundant in fruits produced by 100 ppm though sprays of 150 ppm concentration produced a higher number of seedless fruits.

A mixture of 100 ppm gibberellic acid with 100 ppm boric acid sprayed in 1960, further improved the fruit-setting and was thus superior to the spray of gibberellic acid alone.

The calyx in fruits produced by gibberellic acid sprays, became fleshy and persistant and surface of fruits became highly undulated due to uneven thickening of ovary wall (Fig. 3). Fruits with seeds were always bigger in size and ripened later than the seedless ones.

Sections of few ovaries, collected from the above treatments six to eight days after pollination showed several fertilized embryo sacs (Fig. 4). In several other ovaries only degenerated ovules were seen and a prolific growth was seen from the central axis as well as placental flanks leading to the initiation of parthenocarpy (Fig. 5). The cells of this new growth were always parenchymatous, rectangular to elongated in shape, rich in cytoplasmic contents and highly chromatic.

The application of plant regulators in lanolin paste produced no tangible results. Lanolin paste with 0·5 and 1·0 per cent naphthalene acetic acid was ineffective, whereas 1·5 per cent proved toxic to most flowers. Gibberellic acid and indolebutyric acid checked the flower drop for fifteen to sixteen days accompanied by an increase in ovary size.

In treatments consisting of pollination of trimmed ovaries and application of sugar agar media containing germinated or ungerminated pollen grains, seedless fruits developed in several cases (Table 2), but all the trimmed ovaries left as control dropped within three or four days. Application of 1·0 per cent indolebutyric acid in lanolin paste further increased the fruit-set (26·6 to 36·4%). Fruits produced by all these treatments were very small and even more deformed than those obtained by gibberellic acid sprays. Most of these fruits showed a hard structure in the centre simulating the seed (Fig. 6), which from the study of transverse sections of ovaries in early stages was found to be an aggregated mass of degenerated ovules with outer integument hardened.

The above treatments of pollinating trimmed ovaries, thus show that the pollen stimulus was essential for the development of seedless fruits and therefore, unpollinated ovaries failed to develop fruits.

DISCUSSION

It is quite clear from the experimental findings that both pollen grains and embryo sacs of *P. Molle* flowers are functional. The failure of fertilization and subsequent shedding of flowers in self-pollination was mainly due to the inhibition of pollen tube growth in the style, *i.e.*, a case of gametophytic type of self-incompatibility. Gametophytic type of self-incompatibility has also been reported in *P. guajava* (Seth, 1959). Balsubramanyam and Rangaswami (1959) have also reported self-sterility in Allahabad Ronnd variety of *P. guajava.* They observed that the pollen grains failed to germinate on stigma in self-pollination, though they were capable of germination 'in vitro'. Cross-pollination in this variety resulted in setting of fruits as well as seeds. This, indicates that both pollen grains and ovules were fertile and non-setting of seeds was only due to the failure of pollen to germinate on its own stigma. This is, therefore, a case of sporophytic type of self-incompatibility and not self-sterility as suggested by them. Sterility has already been clearly distinguished from incompatibility (Crane & Lawrence, 1947; Brewbaker, 1957; Pandey, 1958; Bubar, 1959). Incompatibility is due to the failure of pollen germination on stigma or inhibition of pollen tube growth into the style though both pollen and embryo sacs are functional, whereas, sterility is due to defective pollen, ovules and other abberations. Incompatibility in plants is further broadly divided into two systems (1) gametophytic type and (2) sporophytic type. In gametophytic type, the pollen germinates and penetrates into the style before it is inhibited whereas in the sporophytic type the pollen either does not germinate on an incompatible stigma as in Crucifereae and Compositeae, or more rarely the incompatible pollen penetrates the style and embryo sac at the same rate as compatible pollen, but fertilization fails at some early stage as in cacae.

Lewis and Crowe (1958) have reported that not only plants of same family, but even closely related families show same type of incompatibility. Brewbaker (1957 and 1959) and Brewbaker and Majumdar (1961) have reviewed all the available literature on self-incompatibility and concluded that there is definite relationship between pollen cytology and systems of incompatibility. According to them, plants with bicelled pollen grains show gametophytic type of incompatibility and those with three celled pollen grains show sporophytic type. The only exceptions are Gramineae which has trinucleate pollen and *Theobroma* which has binucleate pollen. The pollen grains of *Psidium* as well as those of other plants of the family *Myrtaceae* are bicelled (Brewbaker, 1959; Seth, 1961) and, therefore, there are greater possibilities of gametophytic type of self-incompatibility than that of sporophytic type.

In the treatments tried for overcoming self-incompatibility, sprays of gibberellic acid were able to induce fruit as well as seed-setting and better results were obtained by the addition of boric acid. It is believed that plant regulators help in overcoming incompatibility in two different ways. They either help by counteracting the inhibitory action of the style or by delaying the shedding of flower and thus giving enough time for pollen tubes to grow. In the present case the gibberellic acid probably induced seed-setting by counter-acting the inhibitory effect of the style because no seeds were formed in other treatments inspite of delayed flower shedding. Boric acid further helped in seed-setting by accelerating the growth of the pollen tubes. It is already proved that boric acid has nothing to do with the counteracting the inhibitory effect of the style (Visser, 1956; Lichte, 1957). Several investigators have been able to overcome incompatibility either by trimming style or by injecting the pollen grains directly into the ovary (Mangelsdorf and Reeves, 1931; Swaminathan, 1955; Swaminathan and Murty 1957; Maheshwari and Kanta, 1961). These techniques have generally succeeded in those cases where cross fails either due to excessive length of the style or due to the unfavourable medium presented by the style through which the pollen tube has to pass. The present investigations show that in *Psidium* species when the pollen grains with culture media were placed directly on the cut surface of the ovary close to the ovules, only few seedless fruits develop. This may be due to the fact that either the ovary has also inhibitory character or simply by chance none of the pollen tube was able to reach the embryo sac. Inhibitory character of ovary has been observed in several plants (Brewbaker and Majumdar, 1961). The pollination, however, showed its influence in these treatments, because seedless fruits were obtained only in the pollinated ovaries.

SUMMARY

Both pollen grains and embryo sacs of *P. molle* were functional but fruit and seed-setting failed in self-pollinated flowers due to the inhibition of pollen tube inside the style, thus, showing gametophytic type of self-incompatibility.

Sprays of 100 to 150 ppm gibberellic acid at the time of pollinations were able to induce fruit and seed-setting in self-pollinated flowers. A large number of seedless fruits were also obtained in these treatments. The effect of gibberellic acid sprays was further improved when 100 ppm boric acid was added to it. Seeds obtained by these treatments were quite normal and germinated well on sowing. Application of gibberellic acid as well as other plant regulators, *viz.*, indolebutyric acid, naphthalene acetic acid in lanolin paste on the side of the ovary did not produce any effect except checking the shedding of flowers for few days.

Seedless fruits were also obtained by applying germinated or ungerminated pollen grains in sugar (15%), agar (0·5%) media on the trimmed ovaries close to the ovules. Pollination was, however, essential for development of seedless fruits in guava.

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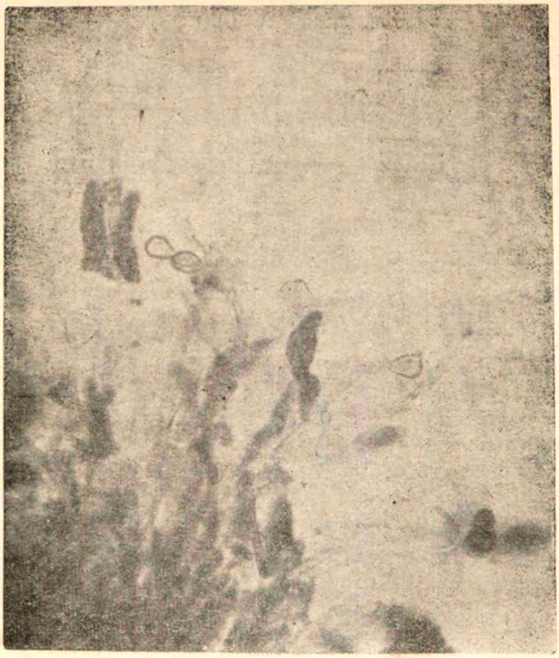


Fig. 1.

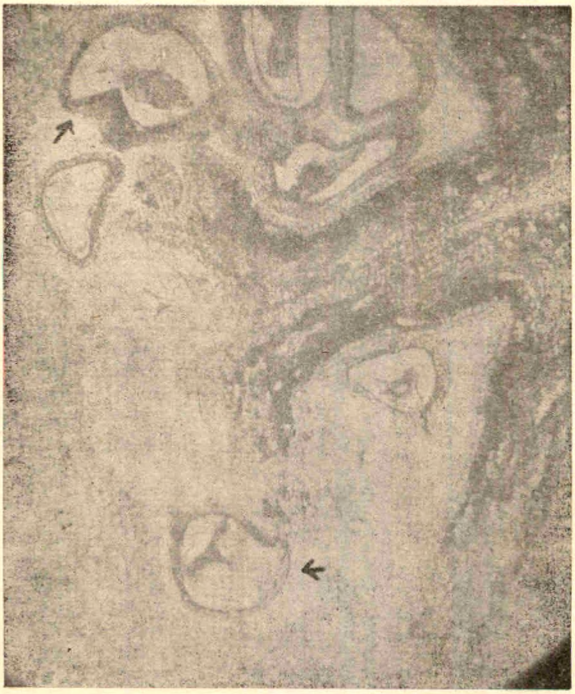
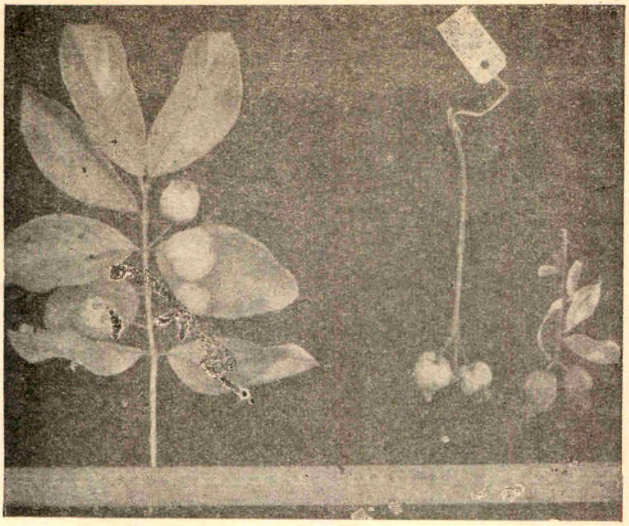


Fig. 2.



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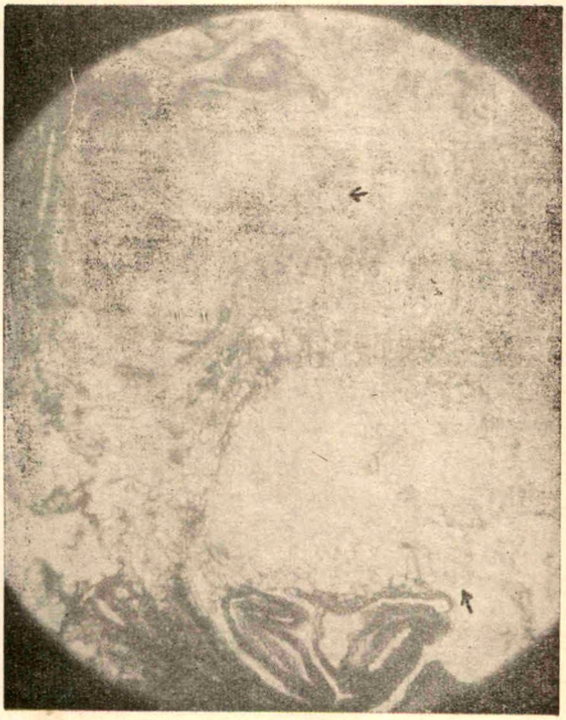

Fig. 4.

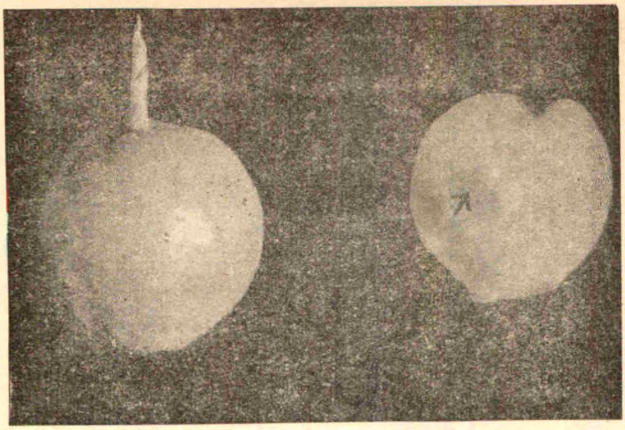

Fig. 5.

THE ENDOSKELETON OF NANDUS NANDUS (CUV.)
PART. I THE SKULL

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Introduction

The Percoid fish *Nandus nandus* (Cuv.) is an excellent example of a fish with canniblastic habits and a very high degree of protrusibility of the mouth. It is evidenced by the study of dead specimens collected from market; some of these having engulfed individuals of their own species of almost their own size.

Nandus nandus has been described by Day (1878) in his book "Fishes of India" as *Nandus mormoratus* (Cuv.) of which he writes as follows : "This species shows great variation in accordance with the localities where it is taken, the serrations on the bones of the head being usually exceedingly indistinct or even absent in specimens obtained in Sind and India as far as Calcutta. But in Assam a considerable difference is perceptible, as most of the specimens have both limbs of the preopercular and also the lower edge of the sub- and inter-operculars serrated, some times rather coarsly so."

Of the group Percomorphi although Tate (1913) writes "The large and varied order Percomorphi occupies a central position among the Teleostean fishes. Still very little work on the osteology of the fishes of this group has been worked out.

It has been, therefore, considered desirable to study the skull of the common Indian Percoid fish *Nandus nandus* (Cuv.) in great detail.

Material and Technique

Specimens of *Nandus nandus* were obtained from fish market of Muzaffarnagar.

The skulls were prepared from fresh specimens by keeping them in a weak solution of caustic soda for a few hours. After removing the flesh, the bones were thoroughly washed. The skulls were, then, kept over night in 10% solution of hydrogen peroxide. Alizarine transparences of the whole fish were also made.

Observations

Head Skeleton

Head Skeleton consists of (A) the cranium and (B) the visceral skeleton.

(A) *Cranium* (Figs. 1,2,3):

The cranium of *Nandus nandus* forms an elongated wedge-shaped structure; its anterior end being thin while the posterior end is thick. The papery bones of the dorsal surface bear three distinct crests on either side. Anteriorly there is a large deep, median groove above the ethmoid, flanked by conspicous processes formed by the nasals and frontals and serving for the reception of the long ascending processes of the premaxillae. The posterior surface of the skull forms an almost straight vertical plate, perforated by the median foramen magnum.

The cranium is distinguishable into 5 regions : (1) the ethmoidal region, (2) the temporal region (3) the orbital region (4) the auditory region and (5) the occipital region.

(1) *The ethmoidal region* (Fig. 4)—The *ethmoid* (et) is a small, oval, elongated and median bone. Posteriorly, it is wedged in between the anterior ends of the frontals. Anteriorly, it articulates with the dorsal plate of the prevomer. The dorsal convex surface is shielded with the posteriorly inclined, ascending processes of the premaxillae, which slide over it.

The *nasals* (na) are a pair of flattened dorsal bones situated in front of the frontals towards the lateral margins of the skull. The anterior end of each nasal comes in contact with the maxilla; posteriorly it articulates with the frontals, laterally with the lacrymal, postero-ventrally with the lateral ethmoid and anteroventrally with the palatine.

The *lateral ethmoids* (let) are paired bones, each carrying a dorsal and two lateral processes. The dorsal process (dp) articulates with the frontal while the lateral processes (lp) articulate with the palatine and lacrymal. The two lateral ethmoids do not meet in the mid-line but are intervened by the ethmoid with which they form an articulation. Each lateral ethmoid articulates with the prevomer anteriorly, frontal posteriorly and parasphenoid ventrally. The body of ethmoid is perforated by a large aperture for the passage of the olfactory nerve.

The *Prevomer* (pv) is a median, comparatively well sized bone, its posterior pointed (p) thin end is attached to the ventral surface of the parasphenoid. Anteriorly the ventral surface of the bone bears a $\wedge$-shaped band of villiform teeth (t). Behind this band there is an oval patch of teeth which touches the former.

(2) *The temporal region* (Fig. 5)—The *parietals* (par) are a pair of small, thin and flat dermal bones situated dorsally on either side of the supraoccipital. The two parietals are separated from each other by the supraoccipital. The dorsal surface of the parietal bears a distinct crest (cr) which is continuous with the outer crest of the frontal in front and with the crest of the epiotic behind. Each parietal articulates anteriorly with the frontal, posteriorly with the epiotic, laterally with the pterotic and mesially with the supraoccipital.

The *frontals* (fr) are extensive papery bones, covering a considerable part of the skull on the dorsal side. The two frontals meet in the mid-line suturally, but diverge anteriorly where the ethmoid bone is wedged. Posteriorly the two frontals articulate with the median supraoccipital. The dorsal surface of each frontal bears two strongly developed crests (cr) running logitudinally, one parallel to the other. The inner crest is better developed than the outer one; it diverges posteriorly to meet the crest of the other side in the mid line while it continues behind with the median crest of the supraoccipital. Ventrally each frontal bears a ridge (frr) towards its inner margin which articulates posteriorly with the pleurosphenoid and prootic. Each frontal is articulated with the ethmoid in the middle, lateral ethmoid below, supraoccipital and parietal behind and sphenotic and pterotic on the lateral side.

The *supratemporals* (spt) are paired, thin, leaf-like ossicles; each of which covers partially the supraoccipital, parietal and epiotic.

The *Basisphenoid* is a small y-shaped bone situated in front of the prootics. The two limbs of the bone articulate with the anterior margins of the prootics, while the lower limb articulates with the parasphenoid below.

The *Pleurosphenoids* (pls) are a pair of small flattened bones situated in front of the prootics. Each bone articulates dorsally with the ventral ridge of the frontal, laterally with the sphenotic and posteriorly with the prootics.

The *Parasphenoid* (pas)) is a mid ventral bone extending from prevomer to the basioccipital. The middle portion of the bone bears on each side a small lateral process (lp) which articulates with the prootic. The parasphenoid articulates anteriorly with the prevomer posteriorly with the basioccipital and antero-laterally with the lateral ethmoids. In the central area, it shields the cranial floor from below and encloses between itself and the cranial floor a bony pocket called the myodome. There is a small patch of villiform teeth (pat) in the middle of the ventral surface.

(3) *The Orbital region* (Fig. 3)—The orbital ring surrounding the eye extends anteriorly as far as the nasal and posteriorly upto the sphenotic.

The *lacrymal* (lcy) articulates with the lateral ethmoid. The postero-ventral margin of the bone bears 2-3 small pointed serrations.

The *pre*-(s1), *infra*-(s2) and *post*-(s3) orbitals lie one behind the other forming ventral boundary of the orbit. The ventral margins of these thin and cylindrical bones are serrated and carry the sensory canals.

(4) *The otic region* (Fig. 7)—The *prootics* (pro) are situated on the ventral surface of the skull. Each prootic gives ventromesially, dorsal and ventral lamellae. The dorsal lamellae meet with each other in the mid-line, while the ventral lamellae remain apart. The inner surface of each prootic is deeply scooped and is continuous posteriorly with the scooped channel of the basioccipital. In these scooped channels are located the sacculi and ampullae of the anterior and lateral semi-circular canals of the internal ear. The ventral surface of the bone is perforated by a pair of apertures (ap) which serve as exit for

the 5th and 7th cranial nerves. Posteriorly, each prootic overlaps the anterior margin of the opisthotic. Each prootic is in contact with a number of bones *i.e.*, with the exoccipital and basioccipital behind, with the pterotic and sphenotic on lateral side and with the pleurosphenoid on the inner side.

The *epiotics* (epo) occupy the postero-dorsal corner of the auditory capsule and extend, somewhat downwards. It forms a longitudinal crest on the dorsal side which is continuous with the crest of the parietal in front. It is in contact with the supraoccipital and exoccipital on its inner side, with the pterotic on lateral side and with the parietal in front. The postero-lateral corner of each epiotic presents a flat articular surface (as) to which the dorsal limb of the post-temporal bone articulates. Internally, its lamina is rolled up to form a bony canal for the passage of the posterior semi-circular canal. It also shares with the exoccipital of its side recess for the reception of the ampullae of the posterior and horizontal semi-circular canal of the membranous labyrinth.

The *pterotics* (pto) form the other pair of auditory bones which are conspicuously irregular in shape. Each articulates with the epiotic on its inner margin, the prootic on the ventral side, the exoccipital behind and the sphenotic in front. Each bone is excavated internally for the passage of the horizontal semi-circular canal. The ventro-lateral surface of the bone bears an elongated facet (hyg) for the reception of the condylar head of the hyomandibular.

The *Sphenotics* (sph) form the anterior most bones of the region, articulating with the frontals and pleurosphenoid, in front and with the pterotic and prootic behind. The ventral surface of the bone bears a deep circular groove, the hyomandibular groove (hyg) for the reception of the condylar head of the hyomandibular. Internally each sphenotic is excavated into a short tunnel for the anterior semicircular canal.

Out of the three otolith, the *Sacculith* (Sagitta) is the largest lying in a depression formed by the basioccipital, exoccipital and prootic. It is a thick massive oval piece showing growth lines (Hickling, 1931) parallel to its lower margin and heavy ridges running vertically from the upper one.

The *Opisthotics* (ops) are flat, irregular bones and do not take any part in the formation of the auditory capsule but remain overlapped by prootics, exoccipitals and pterotics on either side. The posterior margin of the bone bears a deep facet (fc) for the articulation of the ventral prong of the post-temporal.

(5) *The occipital region* (Fig. 6)—The single *supraoccipital* (soc) forms the dorsal and posterior surface of the skull. Anteriorly it extends upto the frontal so as to separate the two parietals from each other. The dorsomedian surface bears a vertical crest (socc) which, extends almost upto the foramen magnum between the two exoccipitals. The crest, in front, bifurcates and each portion

articulates with the dorsal crest of the frontal of its own side. The bone is in contact with the frontals in front and with the parietals and epiotic on the lateral side.

The single *basioccipital* (baoc) of the ventral surface of the skull is a prominent bone. Its anterior two-third portion bears a deep concavity on its inner surface which is divided into two by a short median longitudinal ridge (Fig. 6 A,r). Each concavity serves to lodge a part of the sacculus of the inner ear. The posterior end of the bone is deeply concave (c) and opposed *in situ* to the anterior concave surface of the first vertebra. The dorsal surface of the basioccipital is covered over by the exoccipital plateform and thus shuts off the bone from the region of the foramen magnum (fm).

The exoccipitals (exoc) meet with each other in the mid-dorsal and mid-ventral lines, leaving a large aperture, the foramen magnum (fm) in between. Each exoccipital gives off along the inner sides a horizontal plate which meets with its fellow of the opposite side over the basioccipital. Each bone has an occipital condyle (oc) for the articulation of the skull with the vertebral column. The large and flat articulating surfaces of the condyles are situated on the ventrolateral corner of the foramen magnum. Each bone is in contact ventrally with the basioccipital and prootic, laterally with the pterotic and dorsally with the supraoccipital and epiotic. The bone is perforated laterally by two apertures (ap) which serve as exits for the occipital, vagus and lateralis nerves.

(B) *Visceral skeleton:*

The arches of the visceral skeleton can be studied under 3 sub-heads: (1) Mandibular arch (2) Hyoid arch and (3) Branchial arches.

(1) *Mandibular arch* (Fig. 8)—The *quadrates* (qu) (Fig. 10) are large flattened bones, each bearing a condylar process (cp) for the lower jaw. A depression on the inner surface of the bone, lodges the symplectic. It adjoins the ectopterygoid above, preopercular below, and endopterygoid, metapterygoid and symplectic behind.

The *maxillae* (Fig. 13A) do not bear any teeth, nor do they bind the oral margin. Posteriorly, each maxilla is laterally flattened and slips over the articular of the lower jaw. The anterior end of the bone gives off a dorsal and a ventral processes. The dorsal process has an articular surface (asm) for the reception of the anterior end of the nasal. The dorsal and ventral sides of the ventral process (vqm) have somewhat rounded surfaces which fit into thick cartilaginous or bony caps called the "Submaxillary cartilages". The dorsal cartilage fits against the ventral surface of the ascending process of the premaxilla while the ventral cartilage fits against smooth rounded, condylar-like dorsal surface of the prevomer. With the help of these cartilages, the maxillaries and premaxillaries can rock back and forth as the mouth is protruded and withdrawn.

The *premaxillae* (Fig. 13) are long and curved tooth bearing bones, which together form the entire upper jaw. Each premaxilla bears a number of rows of fine backwardly directed villiform teeth throughout its length. From the anterior end of each premaxilla arises a large ascending process or premaxillary spine (asp), which ascends dorsally and meets its fellow of the opposite side in the mid-line. The ascending processes are very extensive and extend upto the posterior end of the frontals. These processes glide over the ethmoid and frontals in the groove formed by the nasals and crest of the frontals. The anterior edge of each premaxilla gives off a small backwardly directed process.

The *palatines* (Fig. 8, pal) carry a patch of teeth which are continuous behind with the teeth of the ectopterygoid. Anteriorly, the bone bears a small slender process (pap) which adjoins the nasal and maxilla. The base of the process has an articular surface (as) which abuts against the dorsolateral surface of the prevomer. Each palatine overlaps the anterior end of endopterygoid.

The *ectopterygoids* (Fig. 8 ecp) are slender, toothed bones. The inner surface of each bone carries 3 to 4 rows of small pointed teeth. The bone articulates with the palatine in front, quadrate behind and the endopterygoid above.

The *endopterygoids* (Fig. 8, enp) rest upon the ectopterygoids; each articulates with the inner surface of the palatine in front and the quadrate and metapterygoid behind.

The *metapterygoids* (Fig. 8, mtp) are flat bones lying in between the quadrate and hyomandibular. Each bone adjoins the endopterygoid quadrate, hyomandibular and symplectic.

The *dentaries* (dn) (Fig. 13 C) meet with each other in the mid-line by means of connective tissues. In the middle, the dentary bifurcates behind, the two limbs remaining quite apart. The junction of the bifurcated portion of the bone bears a deep groove in which the front end of the articular is inserted. The dorsal margin of the bone, throughout its length, bears three rows of pointed small as well as large teeth.

The *articulars* (Fig. 13 D, ar) are irregular shaped bones situated in the posterior region of the lower jaw behind the dentary. It is also bifurcated into a longer upper (ul) and a smaller lower limb (ll). The upper limb is inserted into the groove of the dentary. Another small process (dp) arises in the posterodorsal margin which is connected with the dorsal limb of the dentary by means of a large ligament. There is a small socket behind, within which moves the condyle of the quadrate. It adjoins the angular below.

The *angulars* (Fig. 13 D, an) are small nodule-like bones articulating with the lower margins of the articular. Each bone lies very close to the articular socket.

(2) *Hyoid arch*—The *hyomandibulars* (Fig. 11, hym) are vertically disposed in the post-orbital region with several short, condyles. There are two prominent condylar heads (hd) on the dorsal edge by which the bone articulates with the pterotic and sphenotic. The corresponding facets for this articulation is situated on the respective bones. The third condyle (opc) is situated on the posterior edge of the bone and serves for the articulation of the opercle. The outer surface of the bone is perforated by a large aperture (ap) for the exit of hyomandibular trunk of the seventh cranial nerve on each side. At the lower extremity of the hyomandibular, three separate bones *viz.*, interhyal, symplectic and metapterygoid are attached to it. The posterior half of the bone remains covered by the preoperculum.

The *symplectics* (Fig. 8, sym) are thin slender bones placed vertically in between the quadrates and the hyomandibulars. Each bone is inserted into the groove of the quadrate in front and articulates with the hyomandibular behind. It also touches the metapterygoid, preoperculum and interoperculum.

The *interhyals* (Fig. 14 A, int) are small rod-like bones located between the epihyal and hyomandibular. Both the ends of the bone are attached to cartilaginous interspaces.

The *Epihyals* (eph) (Fig. 14 B) are laterally flattened bones attached immovably to the ceratohyal. Its posterior margin is slightly bent and thickened to form a small cup-like depression (d) which fits on to the cartilage at the lower end of the interhyal. Each bone is attached in front to the ceratohyal through a thin interspace of cartilage between them. The dorsal side, however, is without any cartilaginous interspace and the two bones articulate through jagged margins, overlaping each other.

The *ceratohyals* (crh) (Fig. 14 C) lie next to the epihyals. The front end of the each ceratohyal is narrow; it shows two articular facets for the attachment with the hypohyals.

Each *hypohyal* (Fig. 14 A & C, hyh) is a double piece of bone lying on either side of the arch. They are small nodule-like pieces attached both on the dorsal and ventral sides to the articular surfaces of the ceratohyal. The ventral pieces of the hypohyals meet each other in the mid-line below the basihyal.

The *Basihyal* (bah) is a single median bone supporting the tongue. It is a flat, elongated piece with broad proximal and distal ends. The hypohyals of the two sides are attached to the lateral margins of the basihyal by fibrous tissue. The upper surface of the bone bears small villiform teeth.

The *branchiostegal rays* (Fig. 14A, brs) are six in number. The first four rays are broad sabre-shaped. They are attached to the outer surfaces of the anterior margin of the epihyal and posterior margin of the ceratohyal. The articulating surfaces of the rays are broad and flat and adhere to the respective bones. The fifth and sixth rays are shorter than the first four rays. They are attached in small grooves present on the inner surface of the ceratohyal.

The *urohyal* (Fig. 14 D) is a thin, vertically situated bone lying close to the angle formed by the mesially meeting halves of the hyoid cornu. It is somewhat triangular in shape; its apex is thickened into a round tuberosity from which two strong and short ligaments proceed to the mesial surfaces of the lower hypohyals on each side. To the posterior end of the bone is attached the pectoral arch through similar ligaments.

Attached along the posterior side of the suspensorium are the bones of the *opercular series.*

The *Operculars* (Fig. 12A, op) are almost triangular in shape, the apex being pointed towards the hyomandibular. Internally, near the apex, lies a facet (fc) for the condyle of the hyomandibular. The inner surface of each opercular has one strongly developed ridge (r) radiating from the facet, extending upto the base of the bone where it forms a spine (sp). There are few sharp serrations (sr) above the spine.

The *preoperculars* (Fig. 12D, prop) are crescent-shaped bones attached to the convex, posterior margin of the suspensorium. Each bone is firmly attached to the hyomandibular and quadrate. Its posterior margin is very thick and serrated (sr). It also joins the symplectic on its anterior margin just below the hyomandibular (Fig. 12 B).

The *interoperculars* (Fig. 12B, inop) are more or less quadrangular bones lying just below the preoperculars. A ligament joins the interopercular with the angular of the lower jaw. The lower margin of the bone is serrated like the preopercular bone.

The *suboperculars* (Fig. 12C, sop) lie behind and below the operculars. Anteriorly, each subopercular is partially overlapped by the interopercular.

(3) *Branchial arches* (Fig. 15 A & B)—There are five pairs of branchial arches of which the first four carry the filamentous and crescent-shaped gills along their outer sides while the fifth is without the gill filaments.

The *basibranchials* (bbr) are three in number situated midventrally one behind the other. The first two basibranchials are bony, while the third is a small cartilaginous piece embedded in the muscles. The first two elements are attached with the three hypobranchials while the cartilaginous piece is directly attached to the ceratobranchial of the fourth arch.

The *hypobranchials* (hyb) are only three pairs attached to the first two basibranchials. All the three hypobranchials carry small minute teeth (t). They are attached to the ceratobranchials of the respective arches.

The *ceratobranchials* (crb) of the first four arches are elongated, rod-like bones grooved longitudinally on their ventral sides; each carries two rows of gill rakers (ra) along their dorsal surface. The gill rakers are in the form of small patches bearing small minute teeth. The fifth ceratobranchials or "inferior pharyngeal bone" (iphb) constitutes the only remanents of the fifth branchial arch. Anteriorly, the fifth ceratobranchial is flattened and lies very close to the ceratobranchial of the other side. It narrows posteriorly into slender rod and is diverged outwards. They also carry curved and pointed dermal teeth (ipht).

The *Epibranchials* (epb) are present only in the first four arches. They are attached to the ceratobranchials of their respective arches and carry rows of gill rakers on their exposed surfaces.

The *pharyngobranchials* (pbr) are four in number and are attached to the first four arches. The first pharyngobranchial is a small rod-like bone attached with the upper end of the first epibranchial. It remains free and does not take part in the formation of the 'Os pharyngeus superior'. The second pharyngobranchial is a flattened piece beset with numerous fine teeth on the inner surface and is attached to the upper surface of the second epibranchials. The third and fourth pharyngobranchials are fused to form a large flattened bone; it is also beset with two sets of numerous fine teeth. The ventral surface of this piece shows three distinct articular surfaces to which are attached the ends of the second, third and fourth epibranchials. The presence of two patches of teeth on this pharyngobranchial probably indicate the fusion of two bones. The second and third pieces of the pharyngobranchials lie very close to each other and are provided with fine teeth on them so as to form the so-called 'Os pharyngeus superior' (Goodrich, 1930).

DISCUSSION

Detailed study of the osteology of *Nandus nandus* emphasises the need for the revision of the present distinguishing characters of the group percomorphi and family Nandidae.

The skull of *Nandus nandus* is of a typical percoid type. The mouth is very much protractile due to the presence of large ascending processes of the premaxillaries. They lie in a groove formed by the nasals in front and frontals behind and extend upto the posterior end of the frontals. These points are the distinguishing characters of the family Nandidae (Regan, 1913).

Large and short ascending processes of premaxillae have been observed in the whole group of Percomorphi (Gregory, 1933). Regan (1913) noted protrusible premaxillae with long ascending processes in *Holocentrus* (Berycoidae).

Allis (1909) concluded that the ascending processes of the premaxillae of mail cheeked fishes and other teleosts are primarily a pair of independent bones which have become fused with the premaxillae. Gregory (1933) after studying a large number of skulls reported that the conclusions of Allis are largely irrelevent. The ascending processes of *Nandus* are very much like *Fundulus* (Gregory, 1933) and they have every appearance of being continuous below with the dentigerous part of the bone. Thus our observations confirms the views of Gregory.

The maxilla in *Nandus* has a dorsal and a ventral process at its anterior end. The dorsal and ventral surfaces of the ventral process fit into thick cartilaginous caps, the submaxillary cartilages. The ventral cartilage fits against smoothly rounded dorsal surface of the prevomer while the ascending process of the premaxillae slides on the dorsal cartilage. As far as we are aware such cartilages have not been reported so far in the fishes of the group percomorphi. However, such cartilages have been reported in carps and suckers (starks 1926; Edward, 1926; Gregory, 1933 and Ramaswami 1952), but the arrangement in these fishes is of a different type.

The great protrusibility of the mouth in *Nandus* is a very characteristic feature. The phenomenon of the protrusibility has been described by Thilo (1920) and Delsman (1926). Gregory (1933) stated that the protrusibility has arisen independently in different groups of fishes. According to Sagemehl (1891), the protrusile condition of the jaws in Eventognathi has doubtless been acquired independently of that of percoid fishes from which it differs in important details.

Like *Scianoides* (Karandikar and Thaku, 1954) and *Aplocheilus* (Kulkarni, 1948) the sacculith (Sagitta) of *Nandus* is situated in a depression formed by the basioccipital, exoccipital and prootic. The absence of the orbitosphenoid as also in Cyprinodont is a feature of the group Percomorphi (Regan, 1913). Its absence has also been reported in other teleostomes like *Osteoglossum, Gonorhynchus* and *Chanos* (Ridewood, 1904). However, it is present in Berycomorphi (Regan, 1929), which according to him has given rise to order Percomorphi.

The basisphenoid in *Nandus* is 'Y' shaped as in *Hoptopteryx lewesiensis* (Regan, 1929) a cretaceous berycoid. Thus *Nandus* lies near the former fish.

The presence of teeth on the jaws, vomer, palatine and parasphenoid is characteristic features of the family Nandidae (Regan, 1913). An extra oval patch of teeth on the ventral surface of the prevomer (vomer of Regan, 1913) behind the anterior band has been observed in *Nandus*. Such a patch of teeth has not been reported by Day (1878) in his specimens of *Nandus*.

Boulenger (1904) listed the absence of an entopterygoid as one of the diagnostic features of family Nandidae. The present investigations reveal that the entopterygoid is present in *Nandus*.

Hubbs (1919) pay considerable attention to the form and arrangement of the branchiostegal rays, in different groups of fishes. His own view is that in higher groups of teleosts there is "A peculiarly constant arrangement of the branchiostegals". The number and arrangement of branchiostegal rays, which are six in number are similar to that of *Aplocheilus* (Kulkarni, 1948) which lies near to the perciformes (Hubbs, 1919).

Nandus nandus found in the water of district Muzaffarnagar, have a serrated preopercular, interopercular, subopercular and pre- and sub-orbitals. Day (1878) reported that serrations on the bones of the head are exceedingly indistinct or even absent in specimens of Sind and India as far as Calcutta. He further reported the presence of serrations in the specimens obtained from Assam.

The vertically extended opercular in *Nandus* bears a prominent spine as present in *Holocentrus ascensionis* (Gregory, 1933). In *Nandus*, unlike other fishes, the inner surface of preopercular has strongly developed ridge on its dorsal side, extending from the articular facet to the posterior margin which forms the above spine.

Gregory (1933) described various articulations of the lower pharyngeal bones in the different species of *Fundulus*. In *F. heteroclitus* he describes "the opposite pharnygeals were elongate, attached only at their anterior ends and diverge posteriorly". The similar condition has been recorded in *Nandus nandus*. Similarly the superior pharyngeals of *F. similis* resembles with the *Nandus* where the three superior pharyngeals on each side are joined to form an oval plate covered with conical teeth.

SUMMARY

Nandus nandus is a typical percoid fish with great protrusibility of the mouth. The ascending processes of the premaxillae are very extensive reaching upto the supraoccipital behind and glide in the groove formed by the margins of the nasals in front and by crests of the frontals behind. The dorsal and ventral processes of the maxilla are covered over by cartilaginous caps.

The parietals are separated by supraoccipital, orbitosphenoid is wanting, basisphenoid is a 'Y'-shaped bone and entopterygoid is present. Teeth are present on the jaws, prevomer, palatines, parasphenoid and branchial arches. An extra oval patch of teeth behind the anterior band on prevomer is also observed. The preoperculars, interoperculars and the orbital bones are serrated. The opercular has a ridge on its inner surface, which ends at posterior end into a spine.

There are only two pharyngobranchials, the second and third pharyngobranchials are fused to form a single bone. The lower pharyngeal bones are attached with each other at their anterior ends and diverge posteriorly. Each sacculith (Sagitta) is a large oval piece situated in a groove formed by the basioccipital, exoccipital and prootic.

ACKNOWLEDGEMENT

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ABBREVIATIONS USED IN THE FIGURES

an	angular	dp	process of dentary
ap	aperture	dpm	dorsal process of maxilla
ar	articular	ecp	ectopterygoid
as	articular surface	enp	endopterygoid
asm	articular surface of maxilla.	epb	epibranchial
asp	premaxillary spine	eph	epihyal
bah	basihyal	epo	epiotic
baoc	basioccipital	et	ethmoid
bbr	basibranchial	exoc	exoccipital
brs	branchiostegal rays	fc	facet.
c	condyle	fm	foramen magnum
car	cartilage	fr	frontal
cp	condylar process	frr	ridge of frontal
cr	crest	g	groove
crb	ceratobranchial	hd	head of hyomandibular
crh	ceratohyal	hyb	hypobranchial
d	depression	hyg	hyomandibular groove
dn	dentary	hyh	hypohyal

hym.........	hyomandibula
inh.........	interhyal
inop...... .	interopercular
iphb......	inferior pharyngeal bone
ipht...... .	teeth of inferior pharyngeal bone
lcy.........	lacrymal
let.........	lateral ethmoid
ll......... .	lower limb of dentary
lp......... .	lateral process of parasphenoid.
mtp.........	metapterygoid
na.........	nasal
oc.........	occipital condyle
op.........	opercular
opc.........	condyle
ops.........	opisthotic
oss.........	os pharyngeus superior
ot......... .	oval patch of teeth
p......... .	posterior end of prevomer
pal.........	palatine
pap...... .	anterior process of palatine
par...... .	parietal
pas.........	parasphenoid
pat.........	teeth of parasphenoid
pbr...... .	pharyngobranchials
pls.........	pleurosphenoid
pro.........	prootic
prop......	preopercular
pto.........	pterotic
pv.........	prevomer
qu.........	quadrate
r......... .	ridge
ra.........	gill rakers
s1......... .	preorbital
s2......... .	infraorbital
s3......... .	postorbital
sc......... .	sensory canal
soc.........	supraoccipital
socc.........	supraoccipital crest
sok.........	socket
sop.........	subopercular
sp.........	spine
sph.........	sphenotic
spht...... .	teeth of pharyngobranchials
spt.........	supratemporal
sr......... .	serrations
sym.........	symplectic
t......... .	teeth
ul.........	upper limb of dentary
vqm......	ventral process of maxilla

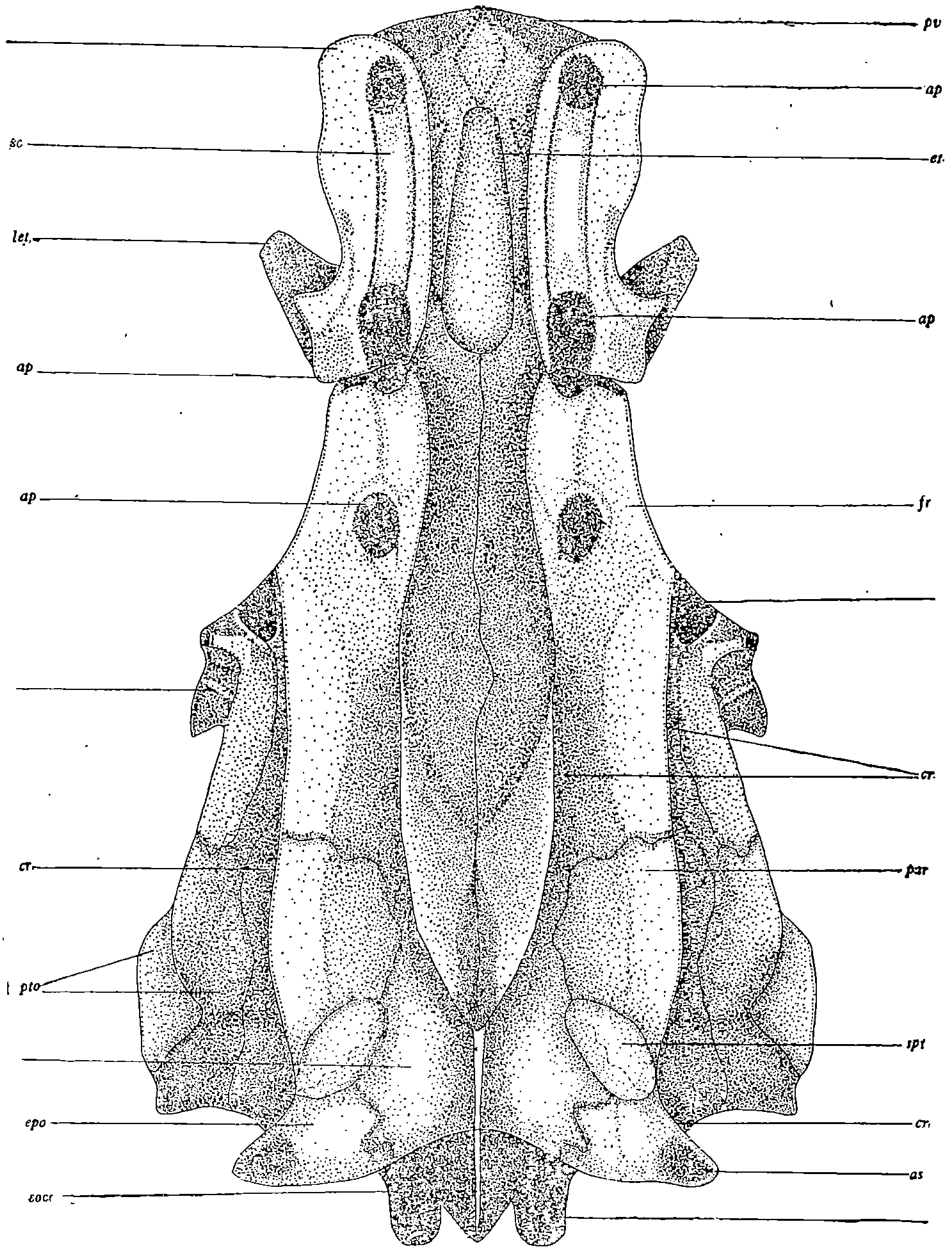


Fig. 1. Dorsal view of skull proper of Nandus nandus.

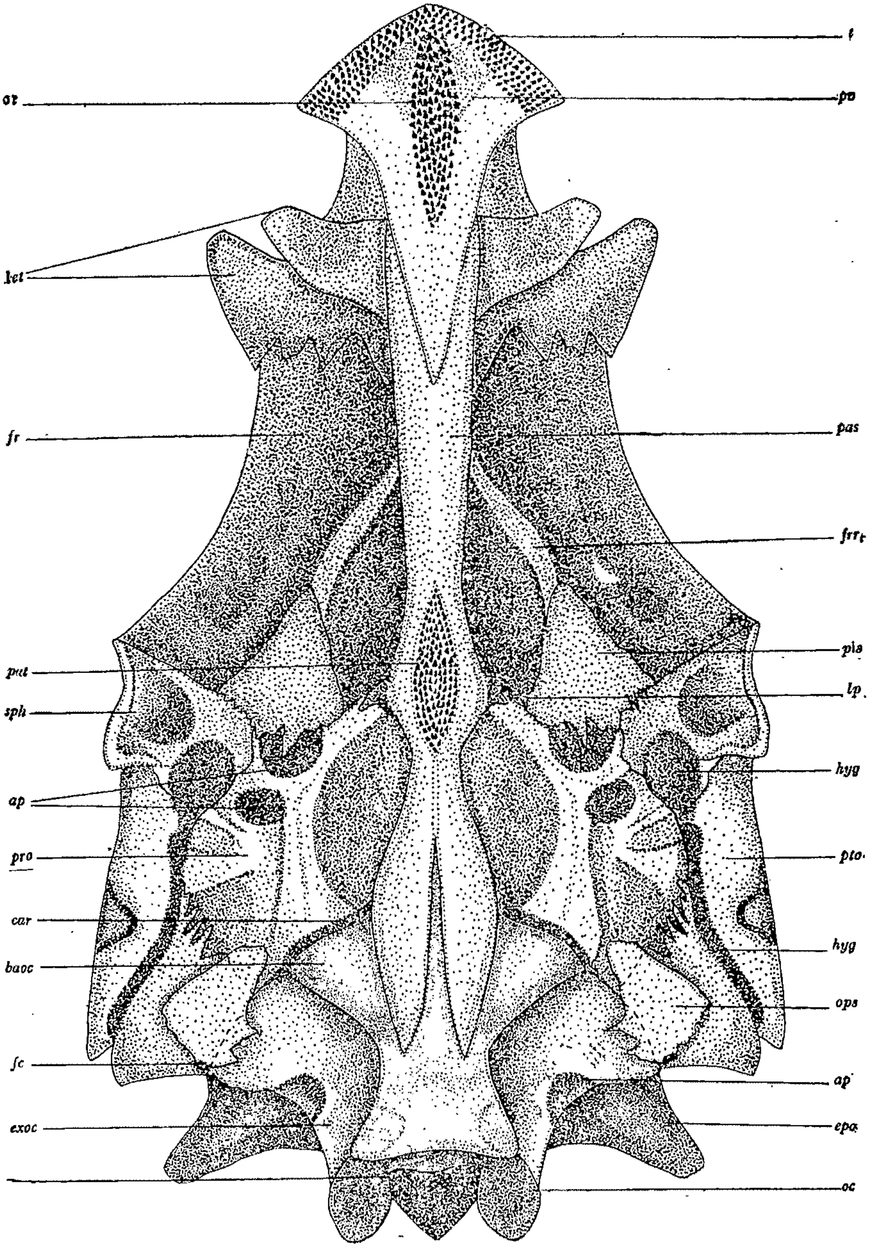


Fig. 2. Ventral view of skull proper of Nandus nandus

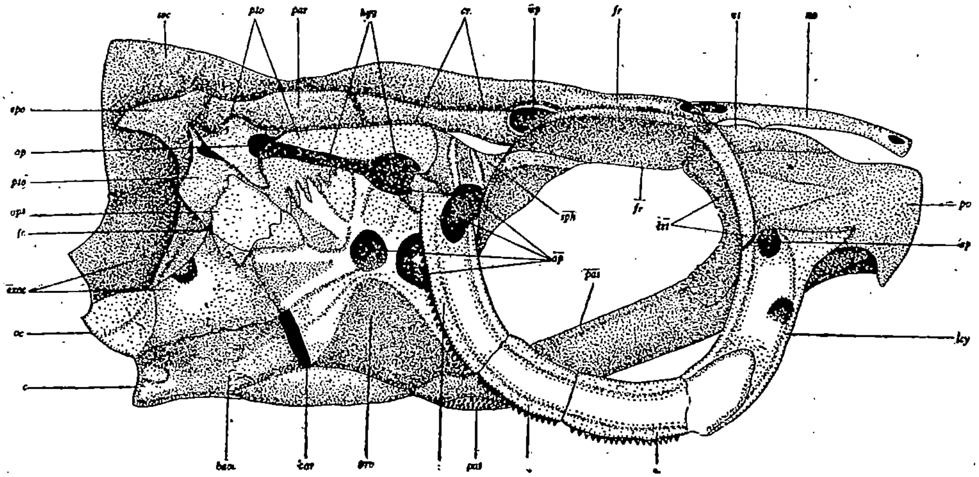


Fig. 3. Lateral view of skull proper of Nandus nandus.

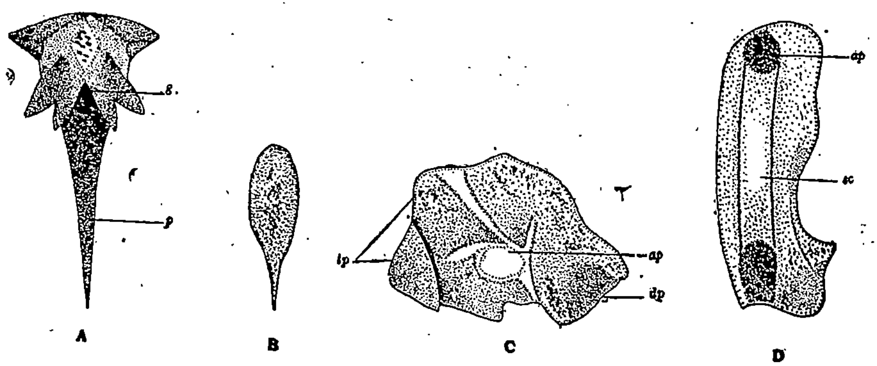
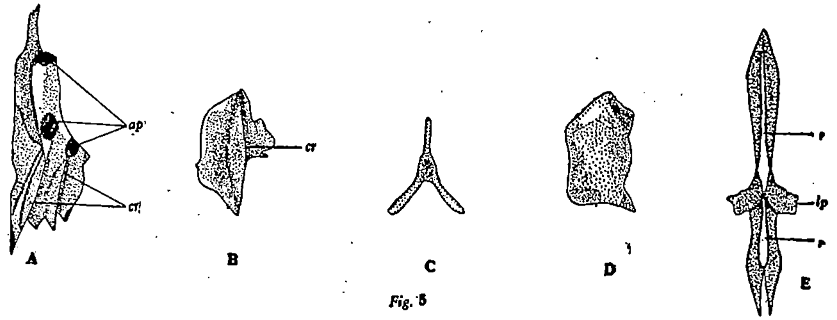


Fig. 4



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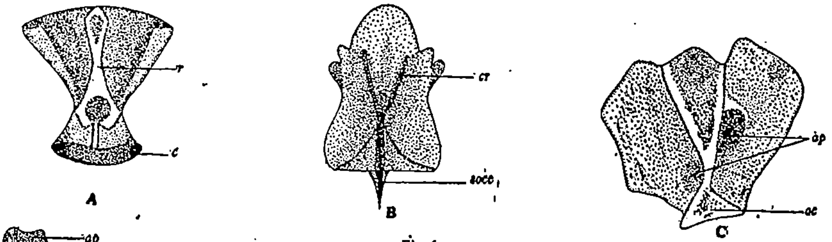

Fig. 6

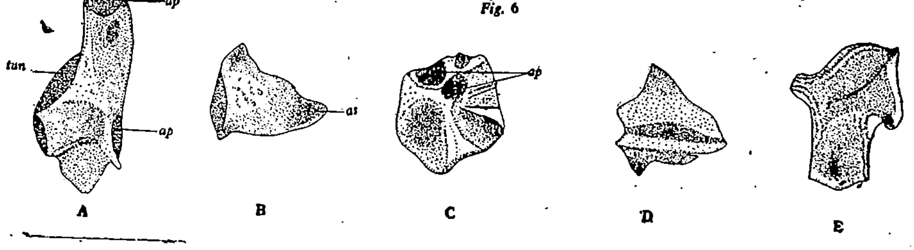

Fig. 4. Disarticulated bones of ethmoidal region.
A. prevomer; B. ethmoid; C. lateral ethmoid; D. nasal.

Fig. 5. Disarticulated bones of the sphenoidal region.
A. frontal; B. parietal; C. basisphenoid; D. pleurosphenoid; E. parasphenoid.

Fig. 6. Disarticulated bones of the sphenoidal region.
A. basioccipital; B. supraoccipital; C. exoccipital.

Fig. 7. Disarticulated bones of the otic region.
A. pterotic; B. epiotic; C. prootic; D. opisthotic; E. sphenotic.

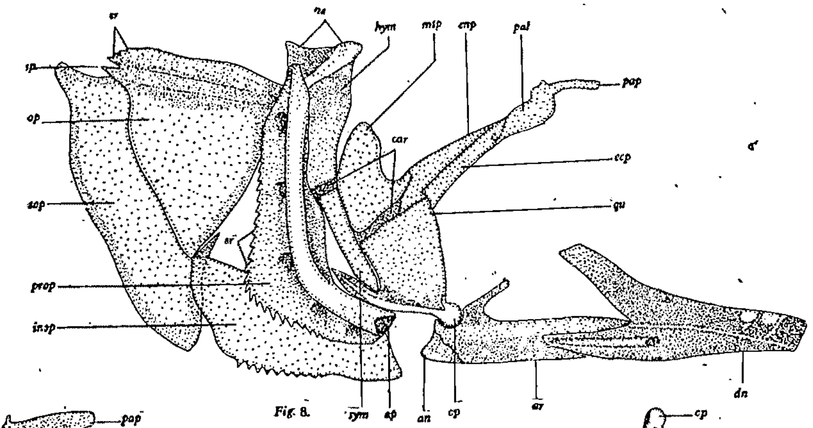

Fig. 8.

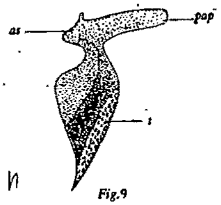

Fig. 9

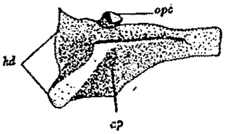

Fig. 11

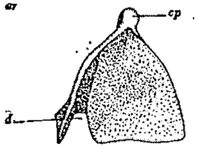

Fig. 10

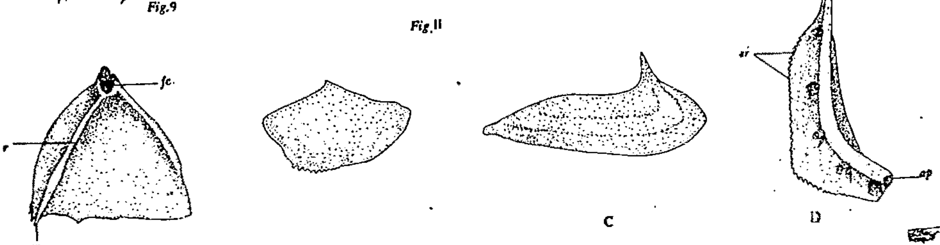

Fig. 12

Fig. 8. Lateral aspect of the bones of right suspensorium, opercular series and associated bones.
Fig. 9. Inner aspect of palatine.
Fig. 10. Inner aspect of quadrate.
Fig. 11. Inner aspect of hyomandibular.
Fig. 12. Loose bones of the opercular series.
A. opercular; B. interopercular; C. subopercular D. preopercular.

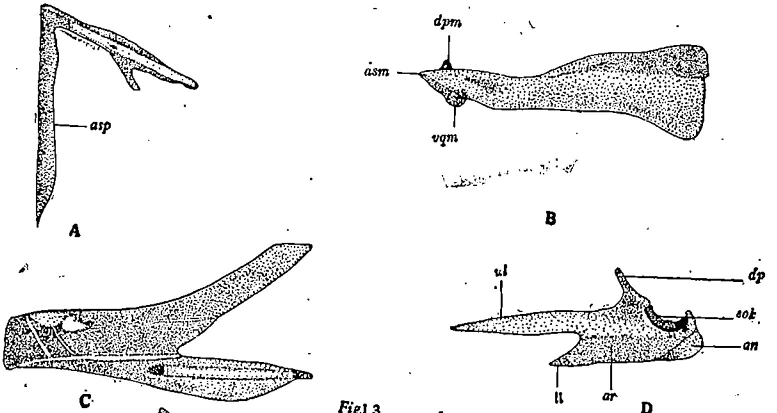

Fig13

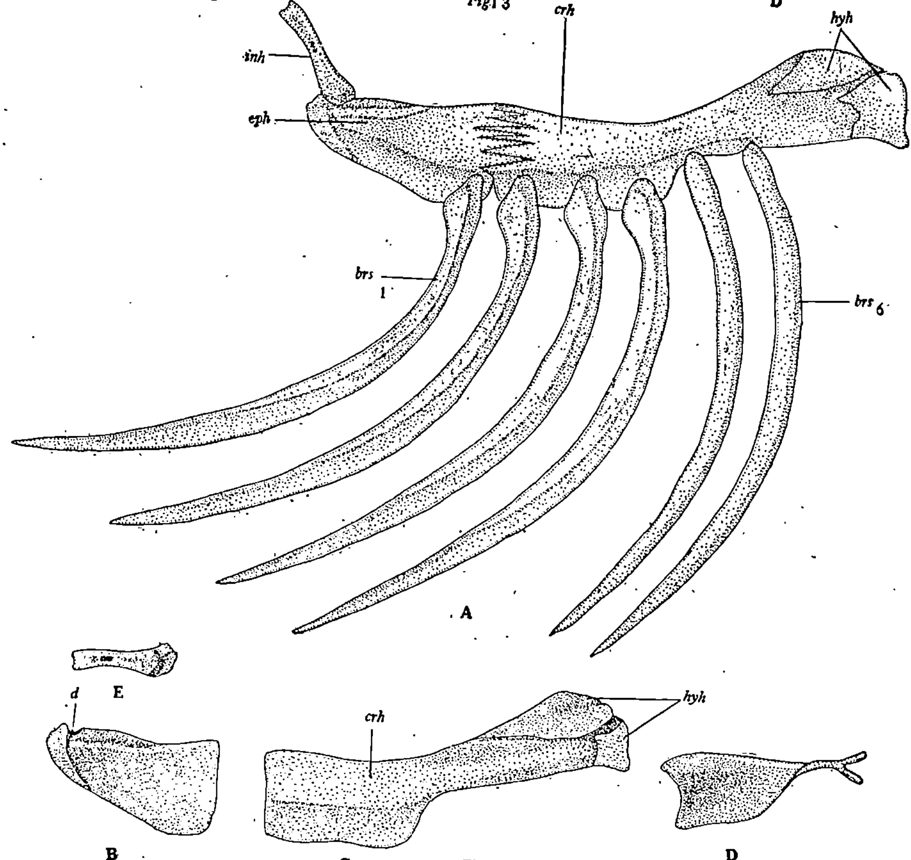

Fig.14

Fig. 13. Bones of the upper and lower jaws.
A. premaxilla; B. maxilla; C. dentary; D. articular and angular.

Fig. 14. Bones of the hyoid cornu and associated bones.
A. hyoid cornu and branchiaostegal rays; B. epihyal; C. ceratohyal and hypohyals; D. urohyal; E. interhyals;

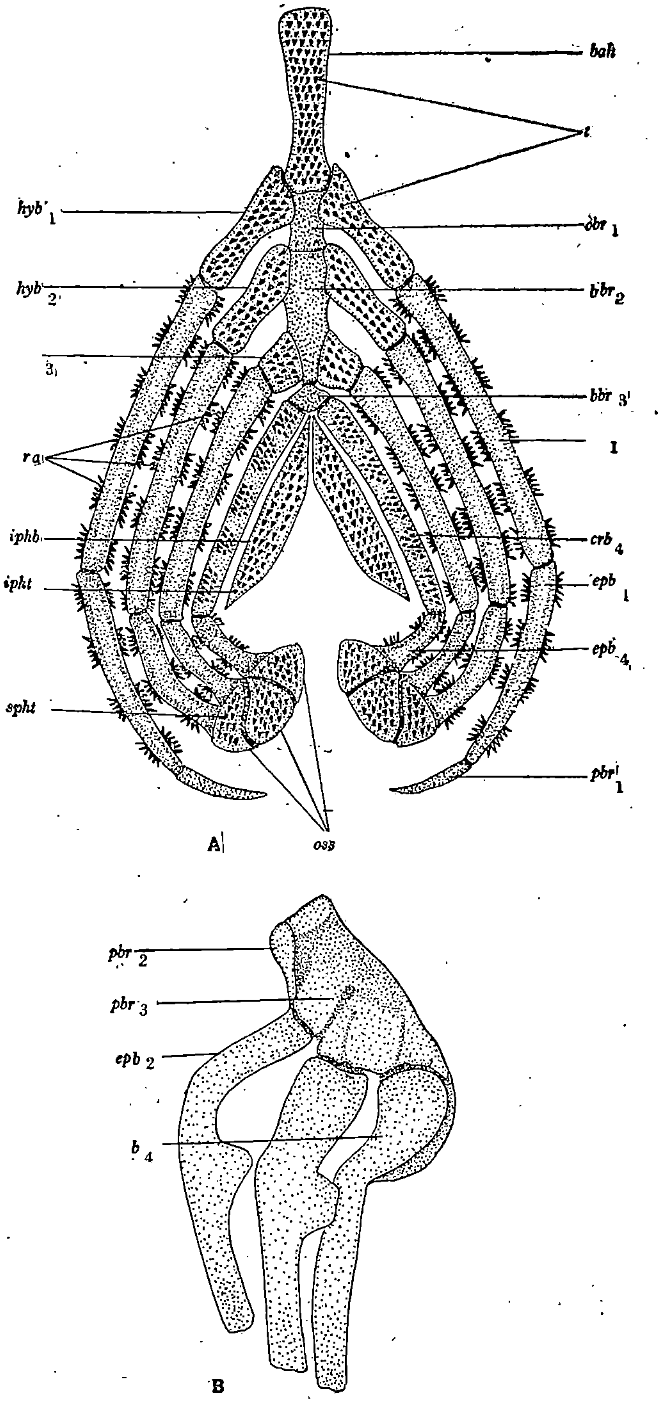

Fig. 15. A. Dorsal view of branchial skeleton.
B. Ventral view of pharyngobranchial showing attachment to the epibranchial.

KINETICS OF Ag^+ CATALYSED OXIDATION OF KETONES BY PERSULPHATE ION—PART II. FURTHER STUDY

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ABSTRACT

The rate of Ag^+ catalysed oxidation of acetone by persulphate ion has been found to be linearly related to C_{Ag^+}, but is almost independent of C_{H^+}. The unimolecular rate constant values decrease slightly with time, but remain constant when the reaction is carried out in the presence of a high concentration of salt. The values of the temperature coefficient, energy of activation and frequency factor gradually increase and of entropy of activation decrease as we go up the homologous series from acetone to methyl-n-propyl ketone. The rate of oxidation of methyl-n-propyl ketone is slightly higher than that of methyl-iso-propyl ketone under the same condition.

INTRODUCTION

During the systematic study of the kinetics of Ag^+ catalysed oxidation of ketones[1] and aldehydes[2,3,4] it was observed that these reactions are unimolecular with respect to S_2O_8'' and zero order with respect to reductant-ketones or aldehydes. The salt effect in all cases is negative and of the primary exponential type. It was considered necessary by us to carry out a comparative study of the rate of oxidation of different ketones in order to elucidate the mechanism of their oxidation. This has been done in unbuffered medium because it was established by us that H^+ ions do not affect the rate to any appreciable extent.

EXPERIMENTAL

G.R., E. Merck, $K_2S_2O_8$ after recrystallisation, acetone of A.R., B.D.H. quality and other ketones of L. R., B. D. H. quality after redistillation were used. The experimental technique was the same as in the previous studies (loc. cit.).

RESULTS OF MEASUREMENTS

Effect of H^+ ions—To find the effect of H^+ ion the reaction was studied in the presence of H_2SO_4, HNO_3 and K_2SO_4 at the same ionic strength. The reaction was also carried out in the presence of a high concentration of K_2SO_4, in the absence and the presence of H_2SO_4. The results of these experiments are summarised in table 1.

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TABLE 1

$CH_3COCH_3=K_2S_2O_8=0\cdot01$ M; $AgNO_3=0\cdot001$ M; Temperature=40°C.

Conc. of added K_2SO_4	Conc. of added acid.	Ionic strength of the reaction mixture	Mean value of k unimol.×10^3
...	...	0·031	4·3580
...	$H_2SO_4=0\cdot01M$	0·061	3·8715
...	$HNO_3=0\cdot03M$	0·061	3·7991
0·01M	...	0·061	3·3906
0·1 M	...	0·331	1·7499
0·1 M	$H_2SO_4=0\cdot01M$	0·361	1·7414

An examination of the above data, keeping in view the negative salt effect, clearly shows that the effect of H^+ ions on this reaction is imperceptible.

Effect of $AgNO_3$—The reaction was studied in the presence of different concentrations of $AgNO_3$; the results are represented graphically in fig. 1, in which the rate constants are plotted against the concentration of $AgNO_3$. The linear graph shows that the rate is directly proportional to $AgNO_3$ concentration.

It has been shown by us in our previous study (loc. cit.) that the value of the unimolecular rate constant in any particular run slightly decreases with time probably on account of the change taking place in the ionic strength as the reaction progresses. To verify this view the reaction was carried out in the presence of a high K_2SO_4 concentration. The results of these experiments with different ketones are given below.

TABLE 2

Ketone=$K_2S_2O_8=0\cdot005$ M; $AgNO_3=0\cdot00075$ M; $K_2SO_4=0\cdot05$ M;
$\mu=0\cdot165$; Temperature=40°C.

Time in Minutes	CH_3COCH_3 k×10^3 (uni.)	$CH_3COC_2H_5$ k×10^3 (uni.)	$C_2H_5COC_2H_5$ k×10^3 (uni.)	$CH_3COC_3H_7$ k×10^3 (uni.)	$CH_3CO.CH(CH_3)CH_3$ k×10^3 (uni.)
2	...	...	...	...	...
30	2·3688	2·1925	2·1467	1·9082*	1·8341*
60	2·2077	2·0131	2·0948	2·0687	2·1640
90	2·1746	2·1119	2·0957	2·1041	2·1302
120	2·1839	2·0200	2·1058	2·1058	2·0936
150	2·1162	2·1708	2·0353	2·1204	2·1645
180	2·1568	2·1046	2·1115	2·1503	2·1748
240	2·1477	2·1394	2·1293	2·1467	2·1467
300	2·1724	2·1028	2·1113	2·1499	2·1278

The above data show that the value of the rate constant in the case of all ketones studied does not decrease with time to any appreciable degree, indicating thereby that the decrease observed in the absence of a high salt concentration was due to the variation of ionic strength of the reaction mixture with the progress of the reaction.

Effect of temperature—The reaction was carried out at different temperatures from 30° to 55°C., the results of which are given below; the rate constant has been evaluated graphically.

TABLE 3

Ketone=$K_2S_2O_8$=0.02 M; $AgNO_3$=0·0005 M,

Ketone	$k\times10^3$ (unimolecular)				
	30°C.	40°C.	45°C.	50°C.	55°C.
Acetone	1·6564	2·2569	9·0658	4·1444	5·9647
Methyl-ethyl ketone	1·4233	1·9680	3·8355	3·7013	5·1689
Di-ethyl ketone	1·4171	1·8424	2·7143	3·5861	5·0954
Methyl-n-propyl ketone	1·3755	1·7746	2·5414	3·5430	5·0666
Methyl-iso-propyl ketone	1·3236	1·6600	2·4707	3·1522	4·6760

The above data show that at all temperatures from 35°C. to 55°C., the rate of oxidation of acetone is highest and it slightly goes down as we go up the homologous series. Further, it is seen that the rate of oxidation of methyl-n-propyl ketone is slightly higher than that of methyl-iso-propyl ketone.

From the above values of the rate constant at different temperatures, the values of temperature coefficient, energy of activation, frequency factor and entropy of activation have been calculated; these are tabulated below.

TABLE 4

Ketone	Mean temperature coeff.	E Energy of activation in Kcals/mol.	A Frequency factor in litre mols. sec^{-1}	$\Delta S^{\neq}$ Entropy of activation E. S. U.
Acetone	1·88	12·67	$2{\cdot}599\times10^{4}$	−38·44
Methyl-ethyl ketone	1·90	12·86	$3{\cdot}097\times10^{4}$	−38·15
Di-ethyl ketone	1·92	13·04	$4{\cdot}010\times10^{4}$	−37·65
Methyl-n-propyl ketone	1·94	13·34	$6{\cdot}279\times10^{4}$	−36·62
Methyl-iso-propyl ketone	1·88	12·76	$2{\cdot}311\times10^{4}$	−38·73

An examination of the above data shows that there is a progressive increase in the values of the temperature coefficient, energy of activation and frequency factor and a progressive decrease in the entropy of activation as we go up the homologous series from acetone to methyl-n-propyl ketone. However, in the case of methyl-iso-propyl ketone the values of temperature coefficient, energy of activation and frequency factor are less than those in the case of isomeric ketone and are even less than those for lower members of the series. This gradual gradation in these values suggests that the mechanism of oxidation of these ketones by persulphate ion is the same in each case and the small difference in their values is due to difference in their structures.

Further work to elucidate the exact mechanism of oxidation of these ketones by persulphate ion is in progress.

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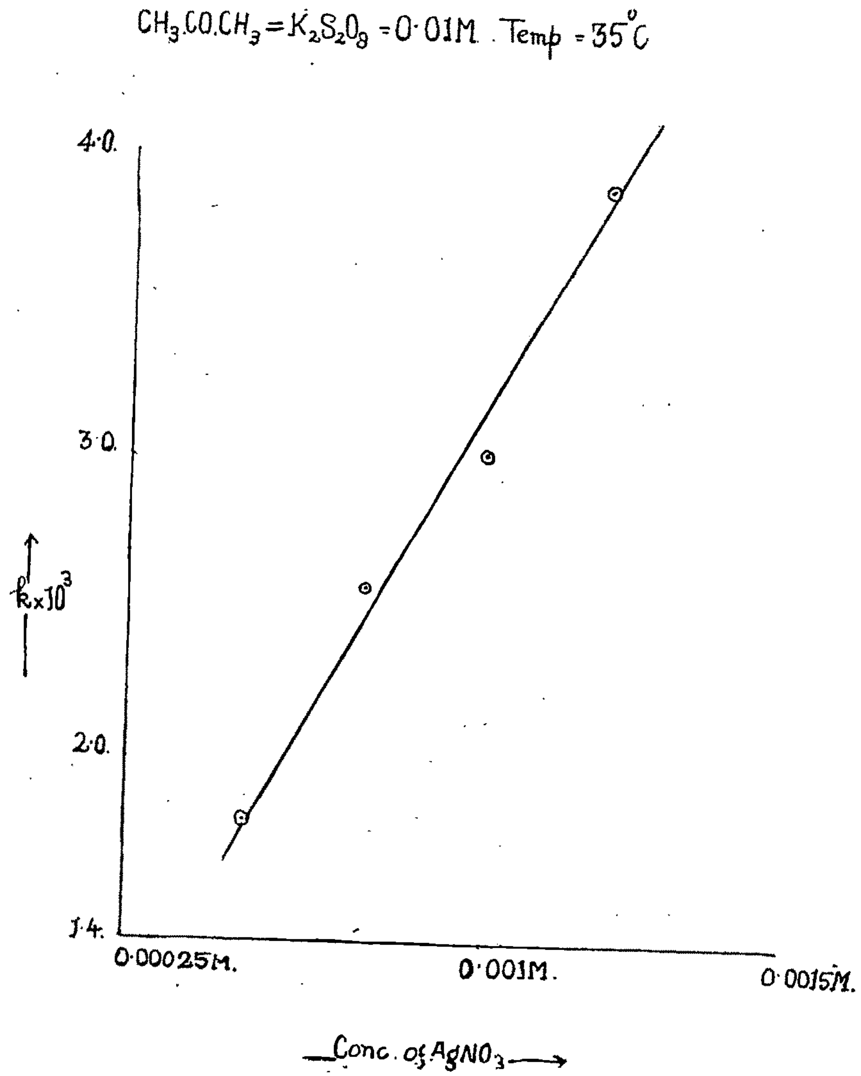
CH3.CO.CH3 = K2S2O8 = 0·01M. Temp = 35°C
4·0.
3·0.
2·0.
1·4.
k×10³
0·00025M.
0·001M.
0·0015M.
Conc. of AgNO3

(Fig. 1)

FLORAL BIOLOGY OF KAMRAKH (*AVERRHOA CARAMBOLA* Linn.)

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Kamrakh or Carambola (*Averrhoa carambola* Linn.) of the family Oxalidaceae, is a tropical fruit. The native home of the species is not definitely known but it is believed to be indigenous to the Malayan region. Under tropical conditions the Kamrakh may flower and ripen fruit in every month, producing several crops a year with peaks in January-February and September-October. But for a few isolated studies on chemical composition of the fruit, very little has been studied and said about some of the basic aspects such as blossom-bud differentiation, floral biology and fruit-set in Kamrakh. So the present studies on blossom-bud differentiation, floral biology and fruit-set in Kamrakh were undertaken during 1962-63.

MATERIALS AND METHODS

Three uniform, about 12 years old seedling, trees of Kamrakh were selected in an orchard near the campus of Government Agricultural College, Kanpur. The trees had been growing under uniform soil management. The studies were started in the month of July, 1962 and were continued till the middle of May 1963.

In Kamrakh flowers emerge both laterally on old wood and also in the axils of current season's growth. So samples of cauliflorus and axillary buds were collected at one week's interval, commencing from 15th of July, 1962 to May, 1963.

The buds were fixed and killed in Formalin-Acetic Alcohol. The material was passed through various grades of Tertiary butyl alcohol for dehydration after Johansen (1940). The sections were cut of 12 microns thickness and they were stained in Haematoxylin.

Observations on time of anthesis were recorded continuously for seven days in the months of August and October. The opened flowers were counted and recorded at hourly intervals and were removed after taking observations to avoid recounting.

Pollen size and shape were studied in methyl green glycerine jelly preparation. Artificial germination of pollen grains was tried in different concentrations of sucrose solutions (*viz.*, 1, 3, 5, 10, 15 and 20%) at room temperature.

Receptivity of stigma was studied both by visual observation and actual fruit-set methods. In the first method stigmas were observed with the help of a hand lens (x10). Shiny yellowish stigmas were considered to be receptive, whereas dried brownish stigmas were treated as non-receptive. In the second method, artificial controlled cross-pollinations were made on previously emasculated flowers of different stigmatic ages and fruit-set was recorded seven days after pollination.

To determine the mode of pollination, four treatments *viz.*, self-pollination, hand self-pollination, cross-pollination by hand and open pollinated flowers were compared. Fifty flowers were selected for each treatment and the fruit-set was recorded in all the cases one week after pollination.

RESULTS

Time of Blossom bud Differentiation:

A broadening and flattening of the apical meristem with two lateral protuberances, one on either side of it, was established as the criterion of blossom bud differentiation. An examination of the buds revealed that the cauliflorus buds began to differentiate from 29th July onwards while the differentiation in axillary buds was observed on 28th October, 1962. It was also observed that differentiation in axillary buds started after the cessation of vegetative growth.

Differentiattion Process:

The vegetative bud arises in the axil of two primary bracts and is enclosed by them in the initial stages (Fig. 1). As the main axis elongates, a number of axillary buds appear on the axis (Fig. 2). Each bud is subtended by a bract. The terminal bud differentiates first and becomes the terminal flower of the cluster (Fig. 3).

The floral parts arise in acropetal succession *viz.*, Calyx, carolla, stamens and pistil (Fig. 4).

Flowering Habit:

Small, frägrant, white and purple variegated flowers are borne in short recemes. These recemes are borne mainly on old wood and the current season's growth (Fig. 5).

The flowers began to appear from the 1st week of August and flowering continued till the middle of May. Thus the period of flowering lasted for nine and a half months. All the branches did not flower simultaneously.

Anthesis:

The percentage of flowers opened, together with meteorological data, are presented in table 1.

TABLE 1

Time of flower opening in Kamrakh during August and October, 1962.

Date	Percentage of flowers found open at hours											Total No. of flowers recorded	Minimum Temperature °C	Maximum Temperature °C	Relative humidity percentage	Rain in past 24 hours ending at 0830 hours (mm.)
	06	07	08	09	10	11	12	13	14	15	16					
11–8–62	1·0	26·5	72·5	...	...	...	...	...	...	...	...	97	26·7	33·9	77·5	0·0
12–8–62	...	30·7	69·3	...	...	...	...	...	...	...	...	140	27·1	35·9	72·5	0·0
13–8–62	...	31·9	68·1	...	...	...	...	...	...	...	...	176	26·4	33·9	76·5	0·5
14–8–62	...	30·5	69·5	...	...	...	...	...	...	...	...	95	24·7	34·5	78·5	8·6
15–8–62	...	3·3	96·7	...	...	...	...	...	...	...	...	93	26·3	32·5	78·0	0·0
16–8–62	...	...	39·4	55·8	4·8	...	...	...	...	...	...	104	25·6	33·4	84·5	32·4
17–8–62	...	...	20·3	69·7	10·0	...	...	...	...	...	...	109	24·9	32·9	95·5	43·2
Average for the week	0·2	17·6	62·2	17·9	2·1											
7–10–62	...	...	...	...	4·3	81·4	14·3	...	...	...	...	182	16·7	31·8	44·0	...
8–10–62	...	...	...	...	...	6·9	34·8	25·2	21·1	12·0	...	100	15·6	31·9	47·5	...
9–10–62	...	...	...	...	...	8·7	33·8	20·0	27·5	10·0	...	160	15·9	32·2	47·5	...
10–10–62	...	...	...	...	...	2·7	26·1	24·6	31·5	15·1	...	142	13·9	32·0	53·0	...
11–10–62	...	...	...	...	...	13·6	29·6	32·1	22·2	2·5	...	162	15·8	33·1	60·5	...
12–10–62	...	...	...	...	3·0	25·0	34·1	15·2	19·3	3·4	...	176	16·4	32·1	59·0	...
13–10–62	...	...	...	...	...	22·2	46·3	17·6	13·0	0·9	...	216	15·2	31·7	55·5	...
Average for the week					1·1	22·9	31·3	19·2	19·2	6·3						

A perusal of table 1 shows that maximum anthesis during August took place between 7 and 8 a.m. However, on 16th and 17th August a very high humidity combined with rains and cloudy weather delayed the anthesis

The anthesis during October was considerably delayed due to low temperature and maximum anthesis took place between 11 a.m. and 2 p.m The dehiscence of anthers started simultaneously with the anthesis.

Pollen Studies:

Soon after dehiscence the pollen grains appeared as a white mass. The exine and intine were thin. Average diameter of pollen grains mounted in methyl green glycerine jelly was 22·88 microns.

Artificial Germination of pollen grains:

The results of pollen grain germination in different concentrations of sugar at room temperature (30-32°C) are given in table 2.

TABLE 2

Percentage of pollen germination in different concentrations of sugar.

Sugar concentrations in the media							
1%	3%	5%	7%	9%	11%	13%	20%
17·2	75·0	47·6	38·3	18·3	4·5	2·1	...

The maximum percentage of germination was observed in 3 per cent sugar solution.

Stigma Receptivity:

(1) *Visual observation*—Receptivity of the stigma was observed with the help of a hand lens (x10). On the day of anthesis, stigmas were receptive with shiny yellowish surfaces; one day after anthesis, stigmas appeared non-receptive as they turned brownish.

(2) *Fruit-set method*—Artificial controlled cross-pollinations were made on previously emasculated flowers at different stigmatic ages and fruit-set was recorded seven days after pollination (Table 3).

TABLE 3

Receptivity of stigma in Kamrakh.

Stigmatal age in relation to anthesis	No. of buds emasculated	No. of buds pollinated	No. of fruits set	Percentage fruit-set
3 days before	50	50	...	...
2 days before	50	50	...	...
1 day before	50	50	...	...
Same day	50	50	22	44
1 day after	50	50	...	...

It is clear from table 3 that stigmas were receptive only on the day of anthesis.

Pollination Studies:

There are no established clonal varieties, so in the present studies self-pollination refers to transfer of pollen from one flower to the stigma of another flower of the same plant and cross pollination means the transference of pollen from one plant to the stigma of flower of another plant. To determine the mode of pollination, the following treatments were compared :—

1. *Self-pollination.* Fully developed and unopened flower buds were bagged before anthesis.

2. *Hand self-pollination.* Flowers were bagged before anthesis and then pollinated by hand from the same plant.

3. *Cross pollination by hand.* Flowers were emasculated and pollinated by hand with the pollen of other plants.

4. *Open pollination.* Flowers were marked with India ink to record fruit-set under natural conditions.

5. *Parthenocarpy.* Emasculated flowers were bagged without pollination.

Fruit-set was recorded after one week and the results are given in table 4.

TABLE 4

Fruit-set during August as affected by various modes of pollination.

Method of pollination	No. of flowers pollinated	Fruit-set after 7 days of pollination	Percentage fruit set
Bagged and left for self-pollination	50	...	...
Hand self-pollination	50	8	16
Hand cross pollination	50	30	60
Open pollination	50	22	44

In hand selfing there was 16% fruit-set while in cross and open pollination the percentage set was 60 and 44 respectively. The main agents of cross pollination were insects. Parthenocarpic fruits were not observed in Kamrakh.

DISCUSSION

In the cauliflorus and axillary buds the differentiation was first noticed on 29th July and 28th October respectively. The differentiation in the axillary buds, thus, started 3 months later. Gibbs and Swarbrick (1930) and Magness (1916) also pointed that in apple, flower bud differentiation in the axillary buds on current season's growth took place a month later than it did on spurs on the same tree.

Blossom bud differentiation in the axillary buds started after the cessation of vegetative growth in winter. Thus it appears that differentiation in axillary buds initiated with the condition favourable for accumulation of a reserve food supply in the current season's growth. Blossom bud differentiation is a continuous process in Kamrakh.

The present studies have revealed that the time of anthesis is governed by the season, especially the maximum temperature. Thus, the time of maximum anthesis during August was between 7 and 8 a.m., while in October, as the day temperature fell down, maximum number of flowers opened between 11 a.m. and 2 p.m. Singh and Dhuria (1960) in sweet lime, Nath and Randhawa (1959) in pomegranate and Randhawa and Dass (1962) in Phalsa observed that with the increase in temperature and decrease in relative humidity the time of anthesis was hastened. On 16th and 17th August, a very high relative humidity combined with rain and cloudy weather delayed anthesis. A very high relative humidity was found to delay anthesis in Phalsa also (Randhawa and Dass, 1962). The dehiscence of anthers started simultaneously with the anthesis.

Studies on stigma receptivity revealed that it was receptive only on the day of anthesis. Such a short duration of receptivity was also found in Phalsa (Randhawa and Dass, 1962).

Self-pollination was not feasible in Kamrakh probably due to unequal length of stamens and pistils. In the variety under study, the stamens were 0·22 cm, in length and pistil 0·40 cm. Hand self-pollination gave 16 per cent fruit-set but the fruits were small, mis-shaped and had only 1-2 seeds as against 5-8 seeds in cross pollinated fruits. This is in agreement with the observation of Darwin (1895) who stated that when the pistils of heterostyled plants are pollinated with pollen from the same flower or from other flowers containing stamens of an equal height, the union may be fruitful but is likely to be attended by varying degree of sterility. It needs further confirmation.

SUMMARY

1. Kamrakh bears flowers both on old wood and in the axils of current season's growth.

2. In cauliflorus and axillary buds the differentiation was first noticed on 29th July and 28th October respectively.

3. The period of differentiation extended over a period of about nine months (July to the end of April) during 1962-63.

4. Flowering started in August and continued till the middle of May. Thus the total period of flowering lasted for 9½ months.

5. Maximum anthesis was recorded between 7 and 8 a. m. during August, while in October it was between 11 a. m. and 2 p. m.

6. The germination of pollen grains was highest in 3% sucrose solution.

7. The stigma was receptive only on the day of anthesis.

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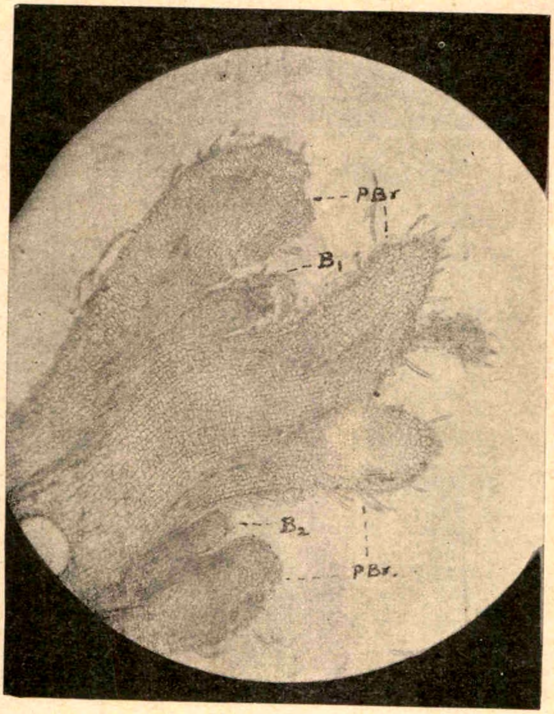

Fig. 1. Vegetative buds (B_1 and B_2) emerging in the axil of primary bracts (PBr). (×75).

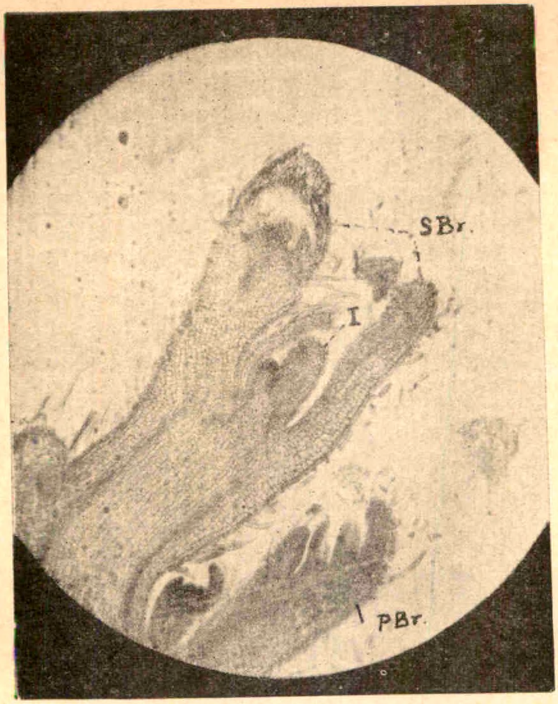

Fig. 2. Pre-differentiated terminal bud (I) subtended by a secondary bract (SBr) (×75)

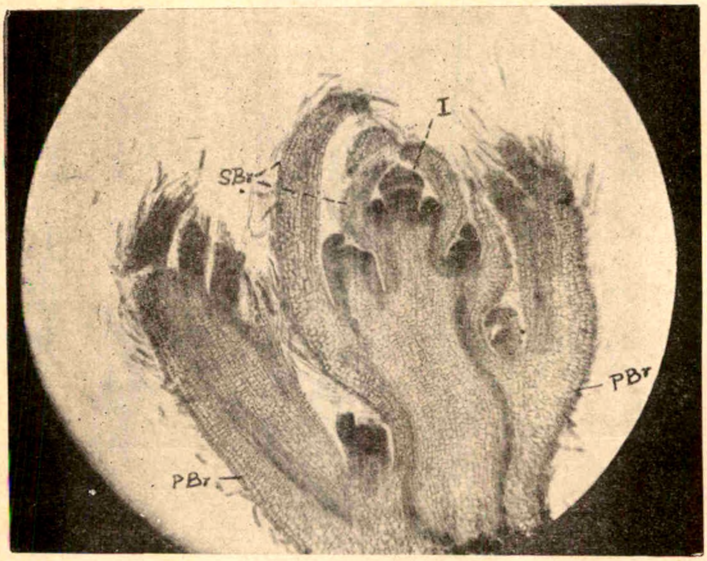

Fig. 3. The terminal bud (I) showing broadening and flattening of the apex, A number of axillary growing points, each subtended by a secondary bract have appeared on the elongated main axis, (×35).

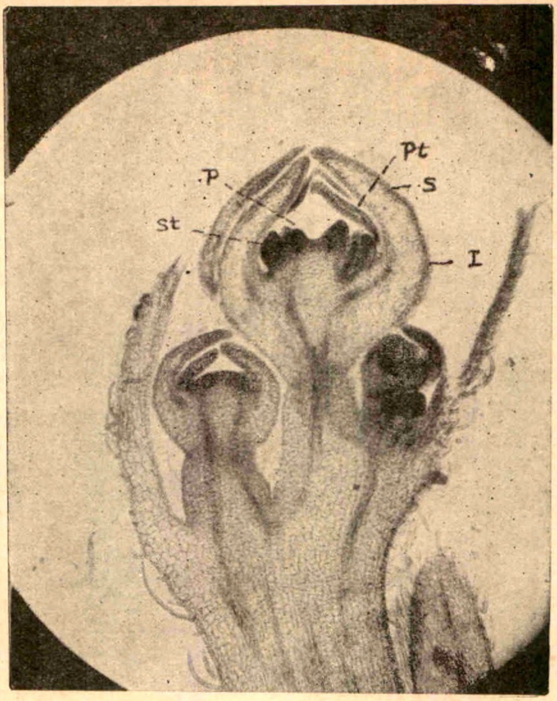

Fig. 4. Bud (I) showing early development of floral parts, S=sepals, Pt=petal, St.=stamen, P=pistil, (×35).

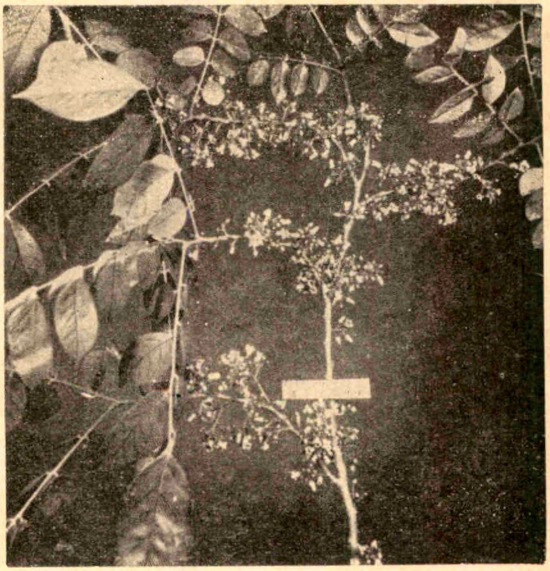

Fig. 5. Cauliflory—the main flowering and bearing habit in kamrakh.

A NEW ECHINOSTOME FROM THE GANGETIC DOLPHIN

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Platanista gangetica, according to Yamaguti (1958), is a host of *Cyclorchis campula* (Cobbold, 1876) Lühe, 1909 and *Brachylaema andersoni* (Cobbold, 1876). One of the three specimens, available for examination, yielded a large number of an echinostome from its small intestine. These, after study of stained permanent mounts, were found to belong to the genus *Stephanopora* Odhner, 1902 (Sub-family Echinostomatinae Odhner, 1910). This genus, well represented in a number of fish-eating birds, has been recorded from some countries and in mammals, according to Yamaguti (1958), it has been reported from *Canis familiaris*, *Larus* spp. and *Zalophus californianus*—the species being *S. denticulata* and *S. denticulatoides*. The Indian reports on this genus are of Bhalerao (1926), Verma (1936), Lal (1939) and Gupta (1962)—all from fish-eating birds. Skrjabin (1956) has included, under *Mesorchis* Dietz, 1909, both these mammalian forms as *M. denticulatus* (Rud., 1802) Dietz, 1909 and *M. pseudodenticulatus* (Mendheim, 1940) Skrjabin and Baschkirova, 1956.

The live specimens were muscular, pinkish and with a spinous cuticle—the cuticular spines being well-developed, somewhat scale-like but never extending behind the anterior testis. The total length, in pressed specimens, ranged between 7·5-14·6 mm. and the breadth was 1·3-4·8 mm. The reniform head collar, of 0·70-0·86 mm. × 1·01-1·15 mm. size, carried a single row of 24 spines, 12 on each side, which were interupted dorsally in the region of oral sucker. The spines measured 0·043-0·071 mm. by 0·02-0·03 mm. The terminal oral sucker measured 0·71-0·90 mm. × 0·67-1·03 mm. It was followed by a prepharynx extending in the region of head collar. The prominent pharynx measured 0·36-0·46 mm. × 0·31-0·53 mm. in size. The oesophagus was 0·57-0·93 mm. in length. The acetabulum, somewhat smaller than the oral sucker, measured 0·43-0·73 mm. × 0·56-0·73 mm. in dimensions. It was situated in the anterior fourth of the body. The spherical testes, in the middle third of the body, lay in tandem—anterior testis being 0·57-1·1 mm. × 0·4-0·76 mm. and posterior one 0·5-1·2 mm. × 0·5-0·8 mm. in size. The preacetabular cirrus sac measured 0·30-0·78 mm. × 0·18-0·38 mm. in size. The median ovary was spherical and pretesticular, measuring 0·17-0·27 mm. × 0·20-0·28 mm in size. The shell gland area lay immediately postero-lateral to ovary. The uterus, coiled between ovary and acetabulum, continued forward to open into the common genital pore situated between the intestinal bifurcation and acetabulum. The vitelline follicles extended from near the level of shell gland area to the posterior extremity, the follicles behind the posterior testis tending to unite. The eggs were yellowish in colour and measured 0·093-0·10 mm. × 0·057-0·064 mm. in size.

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Following Skrjabin (1958), the present form is assigned to *Mesorchis*. Among its many species, it shows greatest resemblance to *M. kasachi* Baschkirowa, 1941 on account of the general topography of its organs and the number of spines, but differs from it in the ratio between the two suckers—the oral sucker in *M. kasachi*, which has a bird as its host, is much smaller than the acetabulum. It is also distinguishable from both *M. denticulatus* and *M. pseudodenticulatus* on account of larger number of collar spines—which in these two species are 22 in number. Accordingly, the material is assigned to a new species, designated herein as *Mesorchis mahendrai**, Sp. Nov.

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* The present species has been named after my teacher Dr. B. C. Mahendra, D. Sc., F.A.Z., F.A.Sc., F.Z.S., F.Z.S.I., Professor and Head of the Zoology Department, Agra College, Agra.

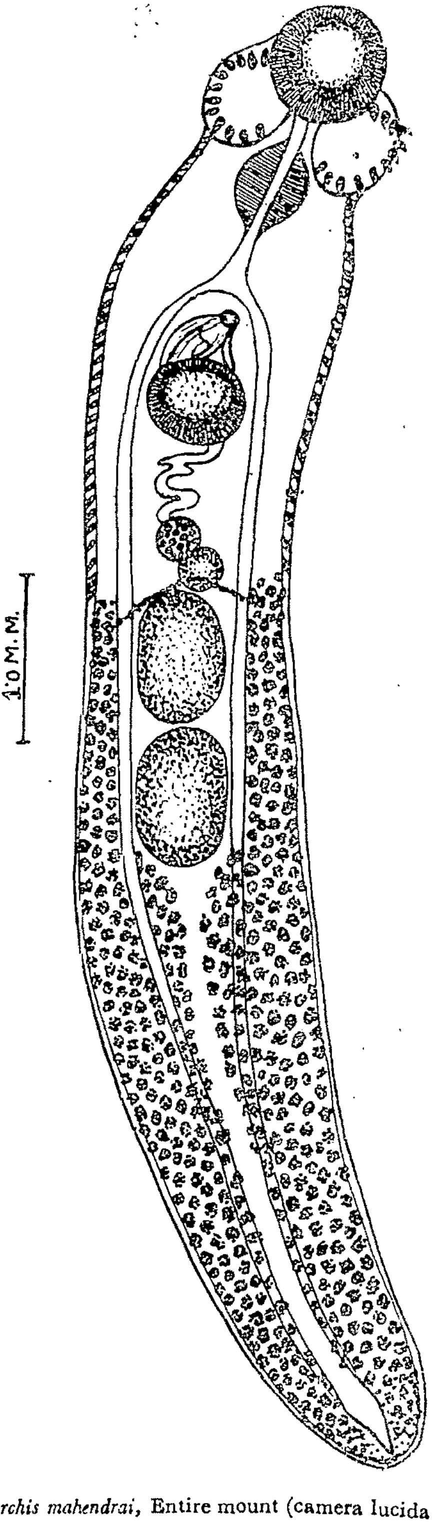

Fig. 1. *Mesorchis mahendrai*, Entire mount (camera lucida drawing).

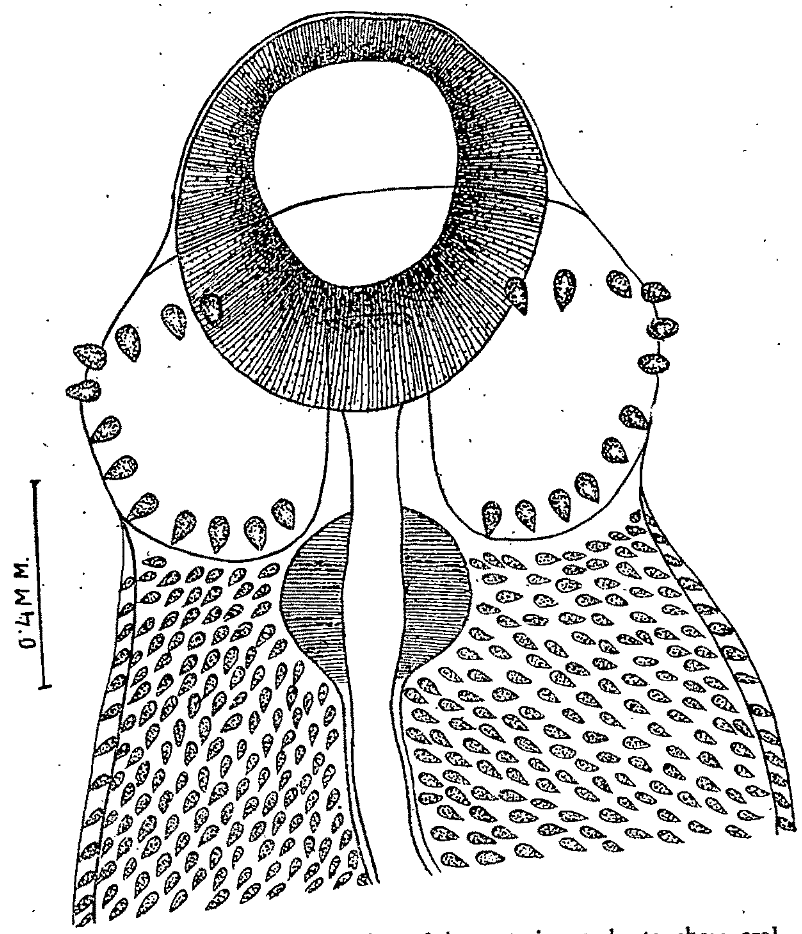

Fig. 2. *Mesorchis mahendrai,* Magnified view of the anterior end to show oral sucker, head collar, collar spines, prepharynx, pharynx and part of oesophagus (camera lucida drawing).

THE VENOUS SYSTEM OF *AMPHIPNOUS CUCHIA* (HAM.)

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Amphipnous cuchia is a fresh water eel, which is found in abundance in this part of the country. In an attempt to describe the vascular system of the teleostean fishes, this interesting fish is first in the series. The system shows certain peculiarities like the absence of the cuverian sinuses and presence of a single posterior cardinal vein.

THE ANTERIOR CARDINAL SYSTEM

The two anterior cardinal veins are equally developed and each is formed of the orbitonalas and maxillomandibular trunks. The *orbitonasal trunk* (I; o.n.t.) is formed of the *nasal vein* (I; n.a.v.) from the ventral side of olfactory capsule and an *orbital vein* (I; o.v.) from the orbit. It follows the course of optic nerve and at the level of optic chiasma unites with the maxillomandibular trunk. A number of fine capillaries from the brain unite into a median *cerebral vein* (I; cb.v.). Passing a short distance infront the cerebral vein forks into two branches, which diverging out open into the respective orbitonasal trunks.

The *maxillomandibular trunk* (I; mx.m.t.) is formed of the maxillary and mandibular veins, just in front the angle of mouth. The *maxillary vein* (I; mx.v.) arises from the upper jaw. It curves backwards and receives a small *premaxillary vein* (I;pmx.v.) from the anterior part of upper jaw. The *mandibular vein* (I;m.v.) starts at the anterior end of lower jaw. It runs back and curves up at the angle of mouth receiving capillaries from the posterior side.

Into the left anterior cardinal vein (II;a.c.) before its entering the sinus venosus, opens a slender inferior jugular vein (II;i.f.j.v.). The two inferior jugulars are equally balanced in the anterior region and unite with each other at the level of fourth *nutrient vein* (II;n.v.). Each jugular is formed by a vein from the mandible and another vein from the hyoid arch and it runs back receiving four *nutrient veins* from the four gills. The entrance of the first and second nutrient vein is closely approximated. The common *inferior jugular vein* runs back on the left side of neck region and enters the left anterior cardinal vein.

A *preopercular* (I;p.op.) and a *postopercular* (II;pt.op.) vein arise from the anterior and posterior regions of operculum. The two veins unite and open into the anterior cardinal vein behind its formation from the *orbitonasal* and *maxillomandibular trunks.* Into the anterior cardinal vein open veins from the gills by a common trunk. The nutrient veins from the first and second gills form a trunk and the nutrient veins from the third and fourth gills combine into another trunk. The trunk of the first and second veins is very small, while that of the third and fourth veins is quite long. These two trunks combine into the main trunk, which opens into the anterior cardinal vein. Into the first nutrient vein open a number of capillaries from the accessory respiratory organs by a single stalk.

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THE POSTERIOR CARDINAL SYSTEM

The posterior cardinal system is represented by the well developed *right posterior cardinal vein* (III; r.p.c.v.), which enters the sinus venosus. The right posterior cardinal starts from the two kidneys by the right and left (II-2.) branches. The two branches soon unite and the single right posterior cardinal runs between the kidneys receiving paired branchlets from the segmental muscles and the substance of kidneys. It finally opens into the right swelling of sinus venosus (II, 3; r.s.s.v.) by an aperture situated posterior to that of the right anterior cardinal vein.

THE HEPATIC PORTAL SYSTEM

The *hepatic portal vein* (III;h.p.v.) is formed by fine branches from the posterior region of intestine. At the posterior end of spleen it receives a *gonadial vein* (III;g.v.) from the gonad. The hepatic portal extends forward receiving capillaries from the stomach, gall bladder and spleen. It enters the liver and breaks up into capillaries in its anterior most region receiving branches from the oesophagus and liver. From the liver arises a system of capillaries, which unite to form two veins. These veins soon combine into a single *hepatic sinus* (III;h.s.) which pierces the septum transversum and opens into the left swelling of sinus venosus (II, 3;l.s.s.v.) by an aperture situated posterior to that of the anterior cardinal vein. A small branch from the anterior part of liver also enters the hepatic sinus.

THE RENAL PORTAL SYSTEM

The blood from the tail region is collected by the *caudal vein* (III;c.d.v.), which runs through the haemal canal of caudal vertebrae. At the level of anus it enters between the two kidneys and bifurcates into two unequal renal portal veins. The left small *renal portal vein* (II, 2; l.r.p.v.) terminates into the left kidney, while the right prominent renal portal vein (II,2;r.p.v.) runs forward and unites with the right posterior cardinal above its bifurcation.

DISCUSSION

The venous system of teleostean fishes has been described by a number of workers. Investigations are on record from Awati and Bal (1934) on *Tetradon oblongus*, Das and Narain (1929) on *Aorea aor* and *Aorea seenghala*, Mott (1950) on *Anguilla anguilla*, Wu and Liu (1943) on *Monopterus javanensis*, Sinha (1956) on *Wallago attu* and Newar (1955) on *Clarias lazera.*

The present discussion is based on variations in venous system of this fish with that of another eel, *Anguilla anguilla* (Mott 1950). The external and inferior jugulars were mentioned in *Anguilla* without any details of their position and distribution. A detailed account of the distribution of the external jugular (anterior cardinal) and inferior jugular veins has been given in *Amphipnous*. The inferior jugulars combine into a single vein after the entering of nutrient veins.

A well developed right posterior cardinal vein and a defective left posterior cardinal vein with anastomosis among them was described in *Anguilla*, while a single right posterior cardinal vein has been found in *Amphipnous*. The gonadial vein was mentioned to open into right posterior cardinal vein in *Anguilla*. It is observed to enter the hepatic portal vein in *Amphipnous*.

The caudal vein was said to divide into two renal portals in *Anguilla*, which terminated in the kidneys. The caudal vein was also reported to become confluent with the hepatic portal by a number of branches. The caudal vein gives off two feeble renal portal veins to the kidneys in *Amphipnous* and opens into the right posterior cardinal vein by the right renal portal vein.

ACKNOWLEDGEMENTS

My acknowledgements are due to Dr. B. M. Sinha and the authorities of the college for providing the necessary facilities for work.

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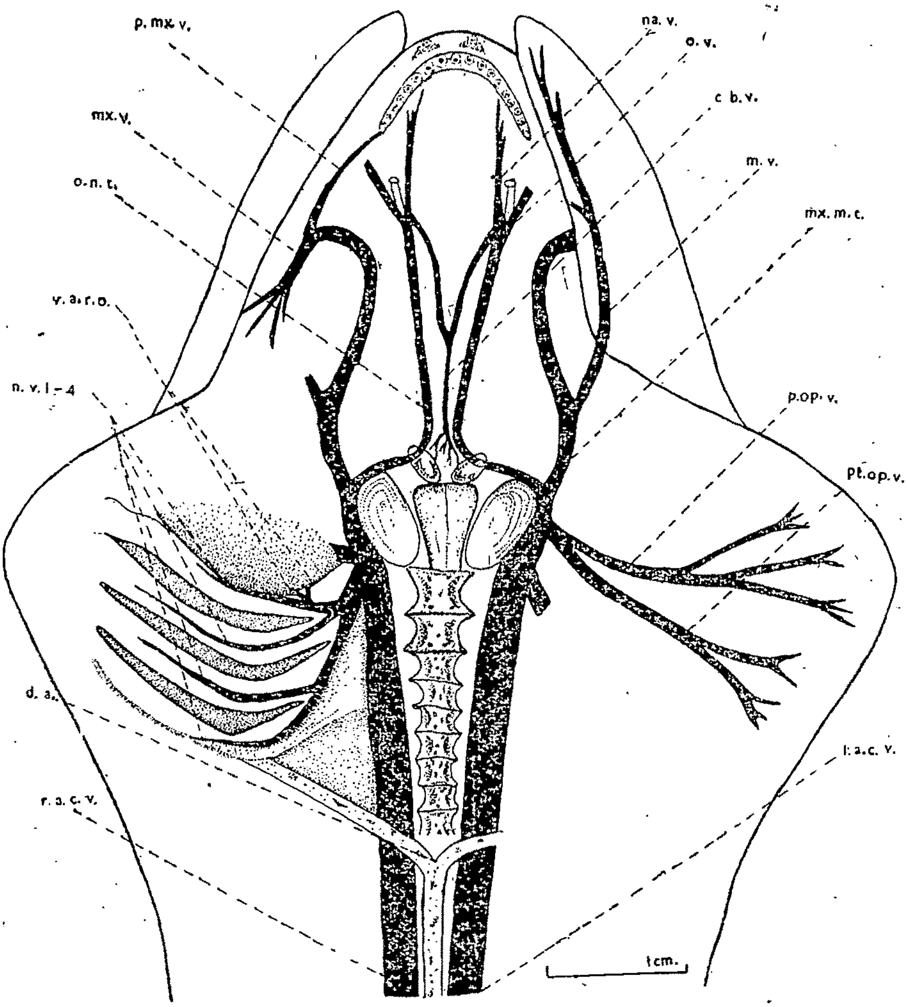
Plate-I

Amphipnous cuchia (Ham.)

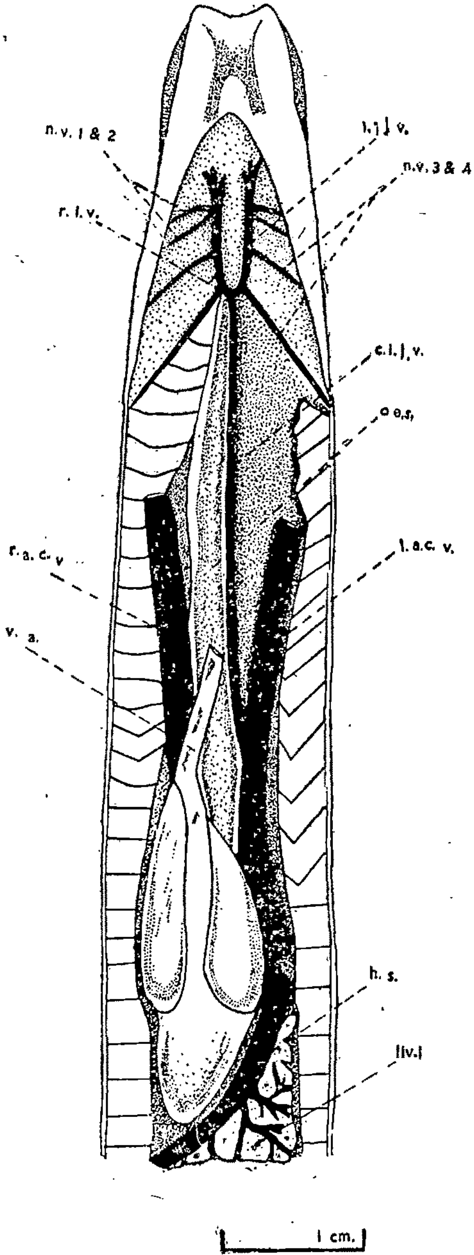


Dorsal Veins

cb. v. cerebral vein; *d. a.* dorsal aorta; *l. a. c. v.* left anterior cardinal vein; *m. v.* mandibular vein; *mx. m. t.* maxillomandibular trunk; *mx. v.* maxillary vein; *na. v* nasal vein; *n. v.* nutrient vein; *o. n. t.* orbito-nasal trunk; *o. v.* orbital vein; *p. mx. v.* premaxillary vein; *p. op. v.* preopercular vein; *pt. op. v.* postopercular vein; *r. a. c. v.* right anterior cardial vein; *v. a. r. o.* veins from accessory respiratory organs.

Amphipnous cuchia (Ham.)

Plate-II



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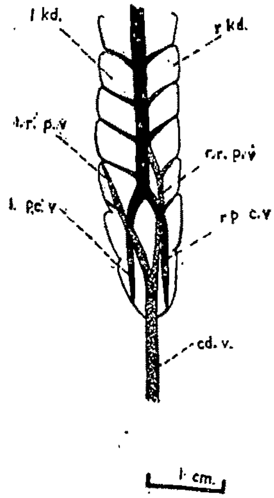

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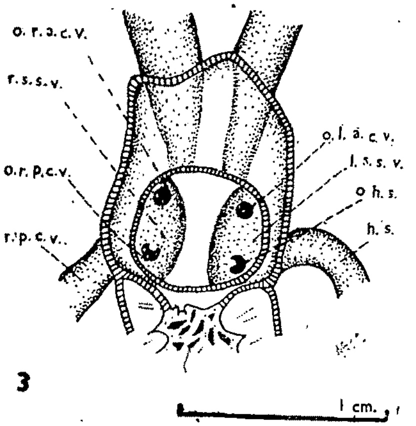
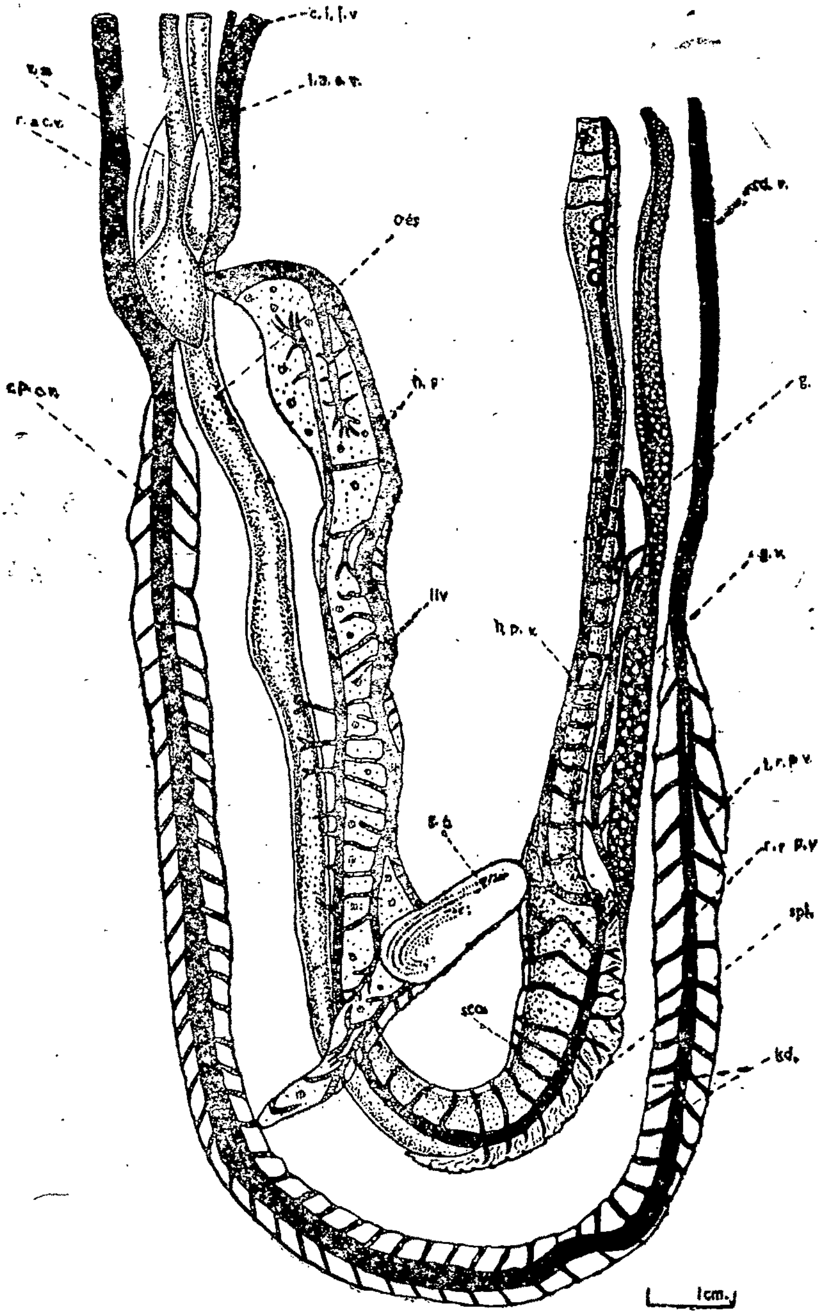


Fig. 1. Ventral veins of anterior region
Fig. 2. Renal Portal System
Fig. 3. Sinus Venosus-showing the entering of veins.

c. i. j. v. common inferior jugular vein; *cd. v.* caudal vein; *h. s.* hepatic sinus; *l. a. c. v.* left anterior cardinal vein; *l. kd.* left kidney; *l. i. j. v.* left inferior jugular vein; *liv.* liver; *l. p. c. v.* left posterior cardinal vein; *l. r. p. v.* left renal portal vein; *l. s. s. v.* left swelling of sinus venosus; *n. v. 1-4* first, second, third and fourth nutrient veins; *oes.* oesophagus; *o. h. s.* opening of hepatic sinus; *o. l. a. c. v.* opening of left anterior cardinal vein; *o. r. a. c. v.* opening of right anterior cardinal vein. *o. r. p. c. v.* opening of right posterior cardinal vein; *r. a. c. v.* right anterior cardinal vein; *r. i. j. v.* right inferior jugular vein; *r. kd.* right kidney; *r. p. c. v.* right posterior cardinal vein; *r. r. p. v.* right renal portal vein; *r. s. s. v.* right swelling of sinus venosus; *v. a.* ventral aorta.

Amphipnous cuchia (Ham.)

Plate-III



Ventral Veins

cd. v. caudal vein; *c. i. j. v.* common inferior jugular vein; *g.* gonad; *gl.* gall bladder; *g. v.* gonadial vein; *h. p. v.* hepatic portal vein; *h. s.* hepatic sinus; *kd.* kidneys; *l. a. c. v.* left anterior cardinal vein; *liv.* liver; *l. r. p. v.* left renal portal vein; *oes.* oesophagus; *r. a. c. v.* right anterior cardinal vein; *r. p. c. v.* right posterior cardinal vein; *r. r. p. v.* right renal portal vein; *sto.* stomach; *spl.* spleen; *v. a.* ventral aorta.

DIGESTION AND EXCRETION IN SYRPHUS BALTEATUS DE GEER (SYRPHIDAE : DIPTERA)*

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INTRODUCTION

There are many workers on the anatomy of digestive tract but a few on the excretory organs in Diptera. Wigglesworth (1929), Dean (1933), Graham-Smith (1934), Barendrecht (1941) and Dixon (1952) studied the anatomy and histology of digestive organs in various flies. Maki (1935) is the only worker to have contributed on the anatomical structure of alimentary canals and their appendages in Syrphids.

Eastham (1925) worked on the physiology of malpighian tubules in Diptera and Pal (1945) made a reference to nephrocytes in some Culicidae. Okada (1955) made comparative studies of the malpighian tubes of the adult Drosophilid flies. This paper deals with the detailed anatomical peculiarities of both digestive and excretory organs in *Syrphus balteatus* De Geer, and is in series with author's other papers[10–14] on the morphology of the same fly.

MATERIAL AND METHOD

The studies on the alimentary canal and malpighian tubules were made by dissecting the freshly killed flies in Ringer's solution. The diagrams of the gross structure were sketched directly from the dissections and the details were studied from the mounted specimens. For the detailed histology of the alimentary tract and malpighian tubules, the material were fixed in Bouin's and Zenker's fixative. 6-8 μ thick sections were cut and stained with Haematoxylin-eosin, Mann's methyl blue-eosin and Mallory's triple stain.

DIGESTIVE SYSTEM

The alimentary canal or the digestive tract of *S. balteatus* is a complicated and highly coiled structure that begins at the base of the labrum in the proboscis and ends in slit-like anus (Figs. 1 & 2; AN), at the posterior end of the abdomen. In a fly measuring about 8·4 mm. in length, the alimentary canal is about 17·75 mm. It is a straight tube up to the middle of the abdominal cavity, beyond which it lies coiled up in the posterior part of the abdomen.

Like all other insects, the alimentary canal is typically divided into three parts *viz.*, the fore-gut or stomodaeum, the mid-gut or mesenteron or ventriculus and the hind-gut or proctodaeum. The stomodaeum is about 2·40 mm. and the hind-gut is about 5·35 mm. long. The mid-gut, longest part of the alimentary canal representing more than half the total length, is the only absorptive part where food is assimilated. At the junction of the fore-gut and the mid-gut there open into the alimentary canal a pair of rather tubular hepatic caecae (HCA). In addition, the malpighian tubules (ANTMAL & POSTMAL) empty into the alimentary canal at the junction of mid-gut and hind-gut.

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Associated with the digestive system is a pair of tubular salivary glands (SGD) which extend posteriorly up to the fourth abdominal segment and open anteriorly through a common duct at the apex of the hypopharynx.

The Fore-gut—It is the shortest (2·40 mm.) and the narrowest part of the alimentary canal beginning at the base of the mediproboscis and extending up to the posterior limits of the prothorax. The three regions of the fore-gut are pharynx*, oesophagus (Figs. 1 & 2; OE) and the crop (CR). The pharynx and the oesophagus are hard to be differentiated externally, but the crop duct (CRD) and the crop are distinctly marked.

The oesophagus (OE) after its emergence from the oesophageal opening in the brain passes through the cervical region and ends at the beginning of the mesothorax where it opens into the anterior part of the mid-gut, known as the cardia (CAR). At its distal end it gives rise to a very prominent oesophageal valve (Fig. 8; OEV) that lies in the anterior end of the mid-gut. The oesophagus is about 1·0 mm. long. Before its entrance into the anterior part of the mid-gut, the oesophagus gives off ventrally a long narrow crop duct (Figs. 1 & 2; CRD, about 6·6 mm. long) which ends up in the third abdominal segment to form a bilobed, thin walled crop (CR) extending into the fourth abdominal segment. The crop has been observed to be full of pollen grains of various types under natural feeding, but under laboratory feeding on sugar solution the former is replaced by the latter. The bilobed condition of the crop is almost obliterated when it is full of sugar solution. Maki (1935) called this sac as the reservoir or the sucking stomach in Syrphidae.

Histology of the fore-gut—As in all other insects, the fore-gut in *S. balteatus* is lined by the following characteristic layers, namely, the inner intimal layer, middle epithelial layer resting on a basement membrane and the outer muscular layers. The histological investigations reveal a clear differentiation of fore-gut into the pharynx and the oesophageal portions.

The Pharynx—The histology of pharynx shows that the anterior part (Fig. 3) has a thick intimal layer (INT) bearing a few backwardly directed intimal spines (INTS), while the posterior portion (Fig. 4) is lined with relatively thin intima (INT). The epithelial wall (EPTH) is devoid of distinct cell boundaries and appears as continuous granular mass of cytoplasm with small widely scattered nuclei. The intimal lining is thrown into 9-11 longitudinal folds. The longitudinal muscle layer (LMCL) outer to the epithelial lining is rather fairly well-developed, while the circular muscles (CM) are almost absent except few bundles in the posterior region.

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* Structure of pharynx appeared in a separate paper titled: Nayar, J. L. 1964, External morphology of head capsule of *Syrphus balteatus* De Geer (Syrphidae: Diptera). *Indian J. Ent.*, **26** (2) : 135-151.

The oesophagus—The oesophagus, the posterior continuation of the pharynx, is rather of a comparatively smaller diameter than the latter. The intimal layer (Fig. 5; INT) shows prominent ridges dividing the lumen into three longitudinal grooves. Anteriorly the spines are absent but in the posterior region up to the opening of the crop duct these are increased in number than the pharyngeal spines. Their backward direction becomes well marked here. Posterior to the opening of the crop-duct, the spines are again absent and the lumen of the oesophagus increases. The acutely backward direction of the spines seem to prevent the back flow of the pollen. The epithelial layer (EPTH) continues to maintain the poor state of development as in the pharynx. Outer to the epithelial layer, the longitudinal muscle layer (LMCL) consists of only a few weak muscle strands. The circular muscles (CM) on the contrary become very well developed and at places comprise more than one layer.

The crop—It arises as a ventral outgrowth of the oesophagus, the anterior part of which is an elongated narrow muscular tube and the posterior part a thin-walled bilobed sac. The section of the crop duct (Fig. 6) shows thick, spinous much folded intima (INT). The epithelium is lost, the longitudinal muscles (LCML) weakened but the circular musculature (CM) consists of two layers of stout circular muscle fibres. A section of the crop sac (Fig. 7) shows almost the same histological details except that the circular muscles (CM) are weakened and the spines (SP) are reduced in number and size.

The oesophageal valve—The oesophageal valve (Fig. 8) is the result of the invagination of the distal part of the oesophagus into the proximal or the anterior end of the mid-gut, known as the cardia (CAR). Like other Dipteron flies (*Calliphora*, Perez, 1910; *Glossina*, Wigglesworth, 1929), the lips of the oesophageal valve are reflected back, enclosing a circular space girdling the base of the valve (OEV). The intimal lining (INT) continues up to the distal end of the tall, columnar cells forming the oesophageal valve (OEV). The intimal lining (INT) of the free hanging surface of the circular plug of the oesophageal valve is thick and remains almost suspended into the mid-gut lumen as three lobes or lips. The presence of these lips guards the opening of the valve and prevents the backward flow of the food column. The circular space surrounding the neck of the valve is filled up with circular muscles (CM) and connective tissue (CT).

The longitudinal muscle strands of the oesophagus continue posteriorly over the cardia as the longitudinal muscles of the mid-gut.

The Mid-gut—The mid-gut is the longest and absorptive part of the alimentary canal as mentioned above. Its diameter is about five times as that of oesophagus in the thoracic region, about ten times in the anterior part of the abdomen and almost twice that of oesophagus in the posterior part. The anterior limb (Figs. 1 & 2; ANTL) of the mid-intestine starting in the anterior part of the mesothorax and passing through the entire length of the thorax up to the fourth abdominal segment, is an almost straight tube, while the posterior limb (PSTL) after the fourth abdominal segment, is thrown into coils in the fifth abdominal segment and passes into the hind-gut at the junction of which open the malpighian tubules. Maki (1935) in Syrphidae calls the anterior part of the mid-gut as the median mid-intestine or 'chyle stomach' and the posterior part the coiling mid-intestine or the proximal intestine.

The anterior limb (ANTL) of the mid-gut in *S. balteatus* is superficially divided into a proximal and a distal part (PANTL & DANTL). The proximal part (PANTL) is a straight tube extending up to the posterior extremity of the thorax and covered externally by small protuberances arranged in longitudinal rows. At the anterior extremity of the proximal part of the anterior limb is a distinct bulb-like portion (about 0·40 mm long) called the **cardia** (CAR) into which opens the oesophageal valve. A narrow constriction clearly separates it posteriorly from the rest of the mid-gut. Hewitt (1907) calls it the proventriculus in *Musca*. From its anterior part, arise laterally a pair of small backwardly directed narrow tube-like structures the enteric or hepatic or gastric caecae (HCA). Each gastric caecum is about 1·10 mm. in length and runs closely parallel to the lateral walls of the anterior part of the mid-gut. Like the proximal part of the straight mid-gut, the hepatic caecae are also covered over by small protuberances.

A distal part (DANTL) of the anterior limb extending posteriorly up to the fourth abdominal segment is inflated proximally immediately behind the proximal limb due to the constant presence of an air-bubble. Unlike the proximal part it is devoid of any external protuberances.

The posterior limb (PSTL) of the mid-gut beginning after the fourth abdominal segment is thrown into coils in the fifth abdominal segment. The coiled part is uniform in diameter and nearly half as thick as the straight proximal part of the anterior limb. The coils are kept in position by the tracheal branches.

Histology of the mid-gut—The histology of the mid-gut differs greatly from the fore-gut in many respects. The epithelial layer (Figs. 9, 10, 11 and 12; EPTH) is highly developed, the intima absent, the longitudinal muscles (LMCL) form an outer most wall below which lie the circular fibres (CM).

The epithelium (EPTH) of the mid-gut in *S. balteatus* comprises mostly of the striated, columnar prominently nucleated cells, which are packed with fine granules and globules of secretory materials (SGLB) towards their inner margins. The regenerative cells (Fig. 11; RC) are very rare and lie scattered singly at the bases of columnar cells. The "nidi" are absent. Schinoda (1927) reports the singly scattered regenerative cells in Diptera. The size of the epithelial cells varies a good deal in the different regions of the mid-gut. In the anterior region (Fig. 9; EPTH) just behind the cardia the epithelium consists of uniformly small cells with prominent nuclei. In the middle part, (Fig. 10; EPTH) the cells are tall with their inner ends packed up with the secretory globules. The epithelial layer posterior to the cardia in the proximal part of the anterior limb of the mid-gut is thrown into evaginations lining the inner surfaces of the external papilla like protuberances. This arrangement resembles the crypt formation of the mid-gut epithelium in Coleoptera, but these evaginations in *S. balteatus* differ from the latter in the absence of any regenerative cells at the base. Posterior to the distal portion of the anterior limb the epithelial cells (Fig. 12; EPTH) are the tallest and exhibit the maximum amount of secretory activities. Cragg (1920) has only described two types of cells in a Tabanid fly, whereas Wigglesworth (1950) has, however, reported three types of cells in Diptera. The inner margin of the epithelium bears a very thick striated or the so-called 'brush border' (Figs. 9-12; BB). Outer to the brush border can be observed the secretion, in the form of small ballon-like globules, which burst in the mid-gut epithelium after attaining a certain size. The epithelial layer is bounded externally by a single layer of thick circular muscles (CM) followed by widely separated rather weak longitudinal muscle strand (LMCL).

Types of mid-gut secretions—Mero- and holocrine secretions are recognised in *S. balteatus.*

Merocrine secretion—Prominent, small secretory globules (Fig. 10; SGLB) are distinctly observed towards the inner surface of the epithelial in the anterior region and the middle of the mid-gut. These liberate the secretory products into the lumen of the mid-gut.

Holocrine secretion—This type of secretion is confined to the posterior region of the mid-gut (Fig. 11). In this case portions of the epithelium are slashed off and thrown into the mid-gut epithelium. By this process the whole of the nuclear contents are liberated into the lumen.

Hepatic caecae—These (Figs. 1 and 2; HCA) are a pair of blind, uniform, tubular processes as evaginations of the proximal end of the mid-gut (cardia). A transverse section shows, dome-shaped, thickly granulated epithelial cells (Fig. 18; EPTH) with distinct nuclei. An indistinct circular muscle layer (CM) lies externally.

The Peritrophic membrane—The subject of peritrophic membrane, in the digestive system, has perhaps attracted the maximum attention of insect morphologists. Efforts have been made to associate the absence of this membrane with the liquid diet of insects while its presence was interpretted to indicate the solid food habit. These contentions have, however, been refuted by divergent evidences that have accumulated in the past. In adult Asilidae (Ousley, 1946), adult Tabanidae (Wigglesworth, 1950) and plant juice feeding larval Cecidomyiidae (Barendrecht, 1941), the absence of peritrophic membrane is recorded. On the other hand Lewis (1950) mentions the formation of the peritrophic membrane only after feeding in Simuliidae.

In *S. balteatus*—the true peritrophic membrane is absent, the thick striated epithelial border (Figs. 10-12; BB) itself seems to provide the protective covering to the epithelium—a function which is generally attributed to this membrane. In some transverse sections of the mid-gut the innermost layer of the striated border appears peeled off and imparts the appearance of the peritrophic membrane. The relatively thickened (mid-gut) striated border in this fly is probably associated with hard, solid pollen feeding in addition to the fluid diet, honey or nectar.

In relation to the absence of the peritrophic membrane, it is significant to note that the girdle of tall, columnar, mid-gut cells surrounding the oesophageal valve which is supposed to secrete the membrane, is absent.

Pyloric valve—The distal end of the mid-gut (Fig. 12; MG), is telescoped into the widened proximal end of the hind-gut (HG). The widened proximal end of the latter forms a sort of capsule or the so-called pylorus (PY). Into the pylorus hangs down the free telescoped end of the mid-gut, which constitutes the pyloric valve (PYV).

The Hind-gut—The proctodaeum or the hind-gut (about 5·35 mm.) starts at the opening of the malpighian tubules into the alimentary canal in the anterior part of the sixth abdominal segment. It is clearly demarcated into an anterior or proximal narrow coiled part, the anterior intestine (Fig. 1 and 2; AINT) leading posteriorly into a dilated pyriform rectal sac (RECS) opening to the outside through a narrow, highly muscular tubular rectum proper (RECT). The rectal sac and the rectum constitute the posterior intestine (PINT). The anterior intestine, which is a highly coiled tube (about 4·15 mm.) lies in the fifth to the seventh abdominal segments and is not differentiated into the ileum and colon. Posteriorly, it opens into the proximal, swollen part of the posterior intestine—the rectal sac. The opening of the anterior intestine into the rectal sac is not guarded by a rectal valve as described in some insects. The rectal sac along with the posterior tubular rectum measures about 1·20 mm. in length. The rectal sac bears four prominent rectal papillae (RECTP), which are distinctly marked externally. The base of each rectal papilla appears as an oval disc with a tracheal branch penetrating through its centre. The rectal papillae are arranged in two pairs on the dorso-lateral walls of the rectal sac. Maki (1935) also reports similar disposition of these papillae in Syrphidae.

Histology of the hind-gut—Posterior to the pyloric valve, open the malpighian tubules, beyond which begins the hind-gut. The hind gut can easily be distinguished from the mid-gut by the presence of well-developed intimal lining.

A section of the proximal part of the anterior intestine (Fig. 13) shows externally a few fibres of longitudinal muscles (LMCL), circular muscle layer (CM) and flat epithelium (EPTH) with distinct nuclei and inner thin slightly folded intimal layer (INT). The intimal lining (INT) of the distal extremity of the anterior intestine (Fig. 14) just anterior to the rectal sac is thrown into irregular longitudinal folds. The intimal spines are absent. The nuclei of the epithelial cells (EPTH) are comparatively longer than that of the fore-gut epithelium cells.

Rectal sac—The anterior intestine continues up to the seventh abdominal segment as a tube of uniform diameter, beyond which suddenly widens to form a pyriform rectal sac (Figs. 1 and 2; RECS) which tapers distally to a narrow thick walled tube before its opening to outside through the anus (AN). The epithelial wall (Fig. 15; EPTH) of the rectal sac invaginates at four places to form the so-called "rectal papillae" (RECP). The epithelial cells of the rectal papilla are distinctly columnar, enclosing a narrow cavity containing the trachea. The intimal lining (INT) over the rectal papilla is comparatively thin as compared to any other region of the posterior intestine. The "rectal papillae" are a characteristic feature of Diptera. External to the epithelial cells is the circular muscle layer (CM), bounded on the out side by a few rather stout longitudinal fibres (LMCL).

Immediately after the rectal sac, the distal part of the posterior intestine narrows down into a short tube—the rectum, which opens to the out side at the anus. The narrow tube (Fig. 16) immediately behind the rectal sac exhibits almost the same histological details as the rectal sac except that the intima (INT) and the epithelial layers (EPTH) are thrown into four long ridges to divide the lumen into four grooves. The terminal part of this tube shows the extreme development of circular muscles (Fig. 17; CM), which function as a sphincter. The folds of the intimal (INT) and epithelial lining (EPTH) in this region become taller and in addition, the space in between the two tall folds, is further produced into secondary longitudinal ridges. Each quadrant contains about two secondary folds.

Salivary glands—There are a pair of accessory digestive glands or the salivary glands (Figs. 1 and 2; SGD) in *S. balteatus*. Each salivary gland is an extremely slender, long, off-white tubular structure running laterally from the fourth abdominal segment up to the head where its duct meets its counter part from the opposite side to form a common salivary duct (SLDCT) before entering the base of the hypopharynx. The transverse section of the gland shows the outer basement membrane (Fig, 19; BM) and an inner layer of glandular nucleated cells (GC) enclosing a wide lumen in the interior. The cytoplasm (CYT) of the cells is compactly packed with the secretory materials.

EXCRETORY SYSTEM

The waste substances are discharged from the body tissues mainly by the malpighian tubules.

Syrphus balteatus has two pairs of long, slender, malpighian tubules. On either side members of a pair unite to form a common tube (Fig. 20; COMT) before opening into the alimentary canal at the junction of mid-gut with the hind-gut. Anterior branch (ANTMAL) of each pair (about 10 mm. in length), on either side runs almost straight anteriorly along the mid-gut up to the second abdominal segment, where it forms a short curve to follow a posterior course. During its backward journey it runs almost parallel to the ascending branch before terminating as a free end in the posterior of the fourth abdominal segment. The ascending and descending limbs thus formed are webbed together by finer branches of the tracheae. The posterior branch of the pair (POSTMAL) (about 6·5 mm. long) runs posteriorly in a convoluted course and terminates in the fifth abdominal segment. The diameter of the tubules in the proximal region is uniformally 0·45 mm. while near the distal end, it is about 0·54 mm. After starvation the tubules were almost colourless while in the fed condition they exhibited light yellow to pink colour. The colouration seems to be due to the accumulation of waste products of metabolic activities.

Histologically, the malpighian tubule shows no distinct peritoneal coat and even the single layer of striated fibres below it is also lacking, though Palm (1946) reported their presence in all orders of insect except Thysaneura, Dermaptera and Thysanoptera. Externally the basement membrane (Figs. 21, 22 and 23; BMB) is fairly distinct and supports the single layer of epithelial cells (EPTH). The cells of epithelial layer are not uniform throughout the length of the tubule. In the proximal region (Fig. 23; EPTH) they are columnar with rounded eosinophilic nucleus (N) containing roughly 30-40 small basophilic granules apart from a conspicuous nucleolus (NU). The nuclear wall is very distinct. The cytoplasm (CYT) of the cells is finely granular. On their inner margin, the cells are bounded by a prominent striated border commonly known as the 'brush border' (BBR). The lumen of the tubule in this region is rather reduced by the invasion of the tall columnar cells. In transverse section the lumen (LU) exhibits a circular out line. This arrangement continues up to about proximal one-third of the tubule.

A careful observation reveals that the epithelial cells (Figs. 21 and 22; EPTH) become flat and elongated with a wider brush border (BBR) in the distal two-thirds of the tubule. The lumen (Fig. 21; LU) no more retains a circular outline in cross section but exhibits an irregular out line more like a cross. The epithelial cells (EPTH) in this region are relatively heavily packed with excretory granules than the proximal region. Therefore, the distal portion seems to be more concerned with the elimination of waste materials. The discharge of the excretory products into the lumen of the tubule seems to take place by diffusion rather than by the bursting of cytoplasmic globules containing excretory products through the brush border (BBR).

General histological observations reveal that the tubule wall closely resembles the epithelium of the mid-gut rather than that of the proctodaeum, the evagination of which gives rise to the tubules. This resemblance to the mid-gut epithelium is caused probably by the secretory nature of the malpighian tubule epithelium.

SUMMARY

The mid-gut is the longest region of the alimentary canal. The fore-gut is the shortest and narrowest part comprising the pharynx, the oesophagus and the crop. The mid-intestine is divided into anterior and posterior limbs. The former is the straight tube and the latter lies coiled up. The 'nidi' are absent and the regenerative cells are singly scattered. Both mero- and holocrine secretions are recognised. The true peritrophic membrane is absent, the thick striated epithelial border itself seems to provide the protective covering to the epithelium. The pyloric valve is poorly developed. The hind gut is demarcated into an anterior coiled part, the rectal sac and the hinder highly muscular tubular rectum. The rectal sac bears four prominent rectal papillae, which are marked externally as oval discs.

Two pairs of long, slender, malpighian tubules are present. On either side, members of a pair, unite to form a common tube before opening into the alimentary canal at the junction of the mid-gut with the hind-gut. Histologically, the malpighian tubule shows no distinct peritoneal coat and even the single layer of striated fibres below it, is also lacking. A single layer of striated epithelial cells is supported on a basement membrane.

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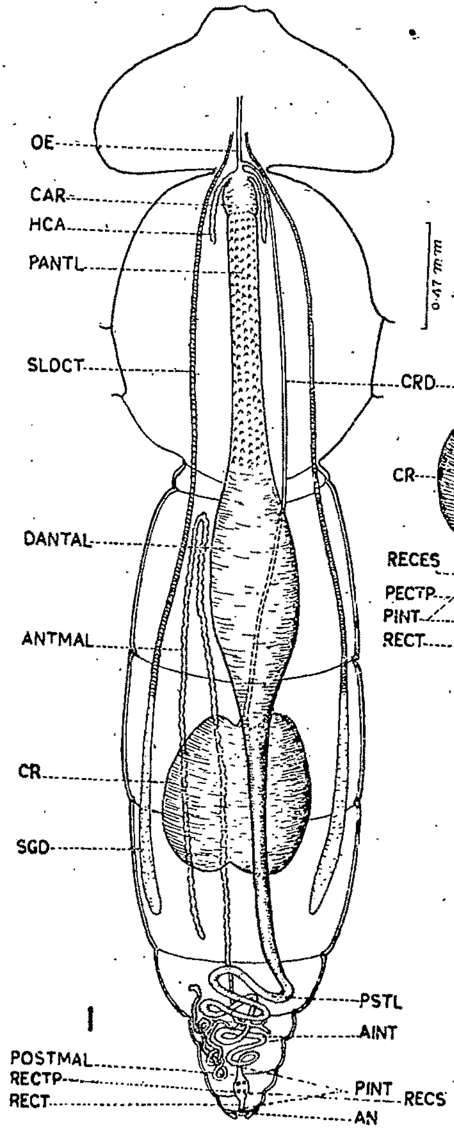
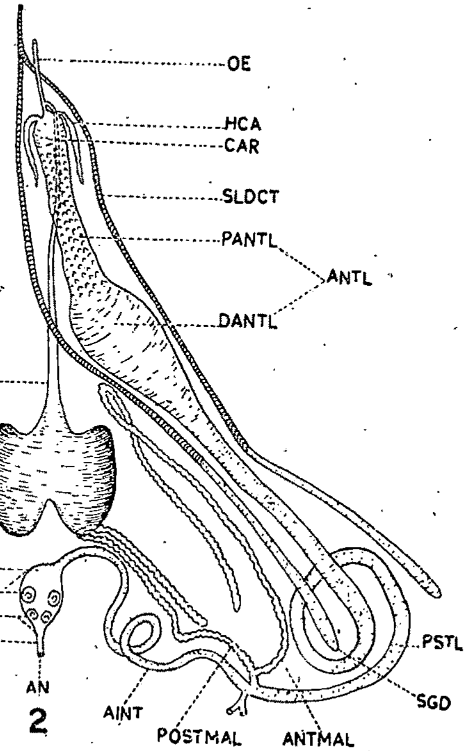




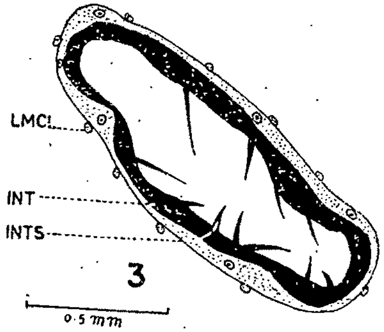
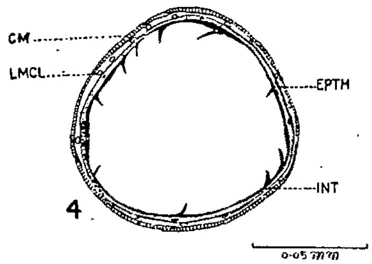


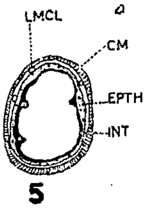
Fig. 1. Alimentary canal in situ.

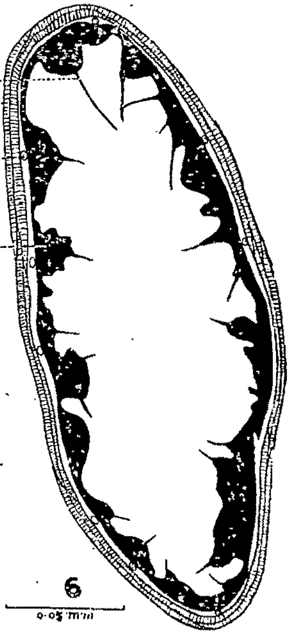
Fig. 2. Alimentary canal with the coils of the mid-gut and the hind-gut opened out to render a clear understanding of the alimentary tract. Only one side of the malpighian tubules of a pair have been completely shown.

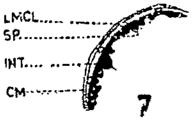
Fig. 3. T. S. of the anterior region of the pharynx.

Aint—Anterior intestine; *An*—Anus; *Antl*—Anterior limb of the mid-gut; *Antmal*—Anterior malpighian tubule; *Car*—Cardia; *Cr*—Crop; *Crd*—Crop duct; *Dantl*—Distal part of the mid-gut; *Hca*—Hepatic caecum; *Int*—Intimal layer; *Ints*—Intimal spines; *Lmcl*—Longitudinal muscles; *Pantl*—Proximal part of the anterior limb of the mid-gut; *Pint*—Posterior intestine; *Postmal*—Posterior malpighian tubule; *Pstl*—Posterior limb of the mid-gut; *Oe*—Oesophagus; *Rect*—Rectal sac; *Rect*—Rectum *Rectp*—Rectal papillae; *Sgd*—Salivary gland; *Sldct*—Salivary duct,









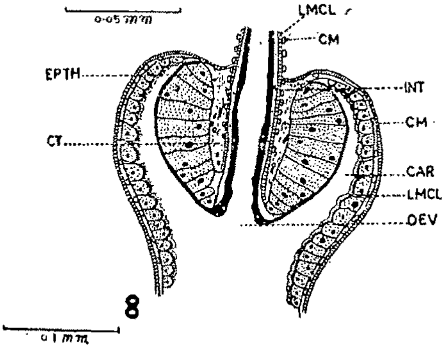
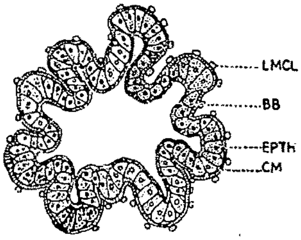


Fig. 4. T. S. of the posterior region of the pharynx.
Fig. 5. T. S. of the oesophagus.
Fig. 6. L. S. of the crop duct.
Fig. 7. T. S. of the crop sac (A part of the wall of the section is shown).
Fig. 8. L. S. of the oesophageal valve.

Car—Cardia; *Cm*—Circular muscles; *Ct*—Connective tissue; *Epth*—Epithelial layer; *Int*—Intima; *Lmcl*—Longitudinal muscles; *Oev*—Oesophageal valve; *Sp*—Spines.



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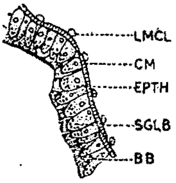

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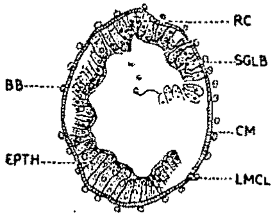

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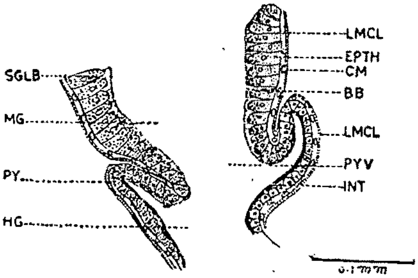

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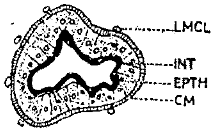

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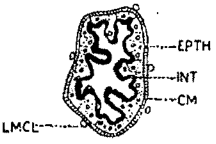

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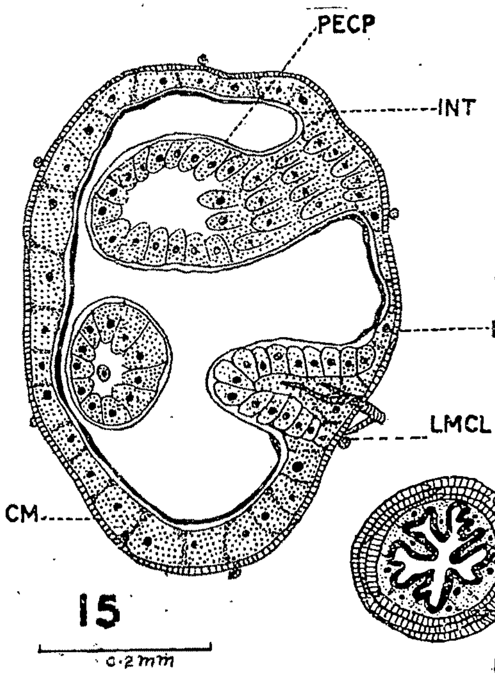
Fig. 9. T. S. anterior part of the mid-gut.
Fig. 10. Epithelial cells of the mid-gut highly enlarged showing secretory globules.
Fig. 11. T. S. of the mid-gut showing delamination of the epithelial wall.
Fig. 12. L. S. of the pyloric valve.
Fig. 13. T. S. anterior part of the hind-gut.
Fig. 14. T. S. of the hind-gut anterior to the rectum.

Bb—Brush border; *Cm*—Circular muscles; *Epth*—Epithelial cells; *Hg*—Hind-gut; *Int*—Intima; *Lmcl*—Longitudinal muscles; *Mc*—Mid-gut; *Py*—Pylorus; *Pyv*—Pyloric valve; *Rc*—Regenerative cell; *Sglb*—Secretory globules.



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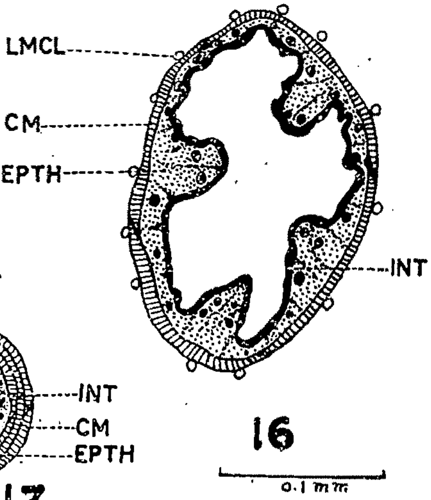

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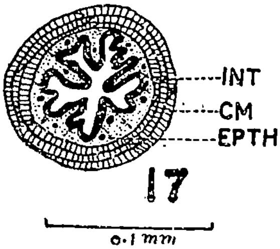

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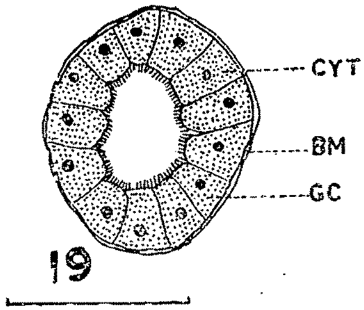

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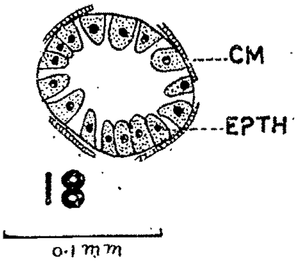

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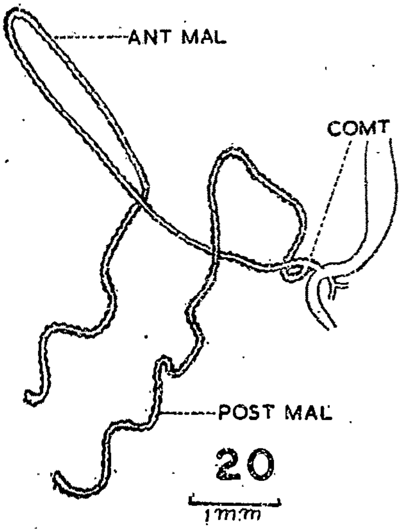
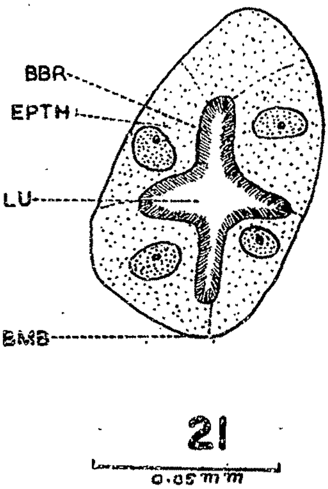
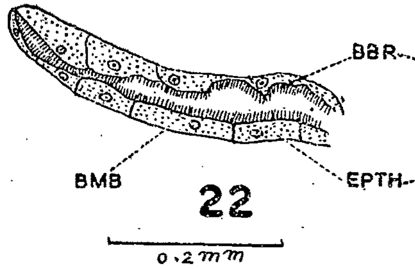
Fig. 15. T. S. of the rectal sac.
Fig. 16. T. S. of the hind-gut just after rectal sac.
Fig. 17. T. S. of the hinder most end of the hind-gut.
Pig. 18. T. S. of the hepatic caecum.
Fig. 19. T.S. of the salivary gland.

Bm—Basement membrane; *Cm*—Circular muscles; *Cyt*—Cytoplasm; *Epth*—Epithelial layer; *Gc*—Glandular cell; *Int*—Intima; *Lmcl*—Longitudinal muscles; *Recp*—Rectal papillae.







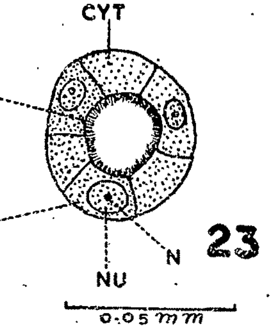


Fig. 20. Malpighian tubules of the one side of the body shown to open into the alimentary canal.

Fig. 21. T. S. of the distal end of the malpighian tubule.

Fig. 22. L S. of the malpighian tubule.

Fig. 23. T. S. of the proximal end of the malpighian tubule.

Antmal—Anterior malpighian tubule; *Bbr*—Brush border; *Bmb*—Basement membrane; *Comt*—Common tube formed by the union of the malpighian tubules of a side; *Cyt*—Cytoplasm; *Epth*—Epithelial layer; *Lu*—Lumen; *N*—Nucleus; *Nu*—Nucleolus.

ABELIAN AND TAUBERIAN THEOREMS FOR THE GENERALISED WHITTAKER TRANSFORM

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Introduction

1. Generalisations of the Laplace integral

$$(1.1) \qquad f(s)=\int_0^\infty e^{-st}\,\phi(t)\,dt$$

or the Laplace-Stieltjes integral

$$(1.2) \qquad f(s)=\int_0^\infty e^{-st}\,d\alpha(t)$$

have been given by Meijer [3], Boas [1] and Varma [5,6]. One of the generalisations given by the last author is in the form

$$(1.3) \qquad f(s)=s\int_0^\infty (2st)^{-\frac{1}{4}}\,W_{k,m}(2st)\phi(t)\,dt$$

where $W_{k,m}(x)$ denotes Whittaker function defined by

$$W_{k,m}(x)=\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}x^{m+\frac{1}{2}}\,e^{-\frac{1}{2}x}\;{}_1F_1\left(\tfrac{1}{2}+m-k;\,2m+1;\,x\right)$$

$$+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\,x^{-m+\frac{1}{2}}\,e^{-\frac{1}{2}x}\;{}_1F_1\left(\tfrac{1}{2}-m-k;\,-2m+1;\,x\right)$$

Here we have taken the transform in the form

$$(1.4) \qquad f(s)=\int_0^\infty (2st)^{\lambda}\,W_{k,m}\,(2st)\phi(t)\,dt$$

and we shall call $f(s)$ the generalised Whittaker transform of $\phi(t)$. This reduces to (1.1) when $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$ because of the identity

$$(2st)^{-\frac{1}{4}}\,W_{\frac{1}{4},\pm\frac{1}{4}}\,(2st)\equiv e^{-st}$$

In this paper I shall obtain the Abelian and Tauberian theorems for the generalised Whittaker transform (1.4).

2. *Abelian theorem.* In this theorem we shall use a function $Q\,(a,b,c)$ which is defined as follows:—

$$Q\,(a,b,c)\equiv\frac{\Gamma(a+b+\frac{1}{2})\,\Gamma(a-b+\frac{1}{2})}{\Gamma(a-c+1)}\;{}_2F_1\left(a+b+\tfrac{1}{2},\,a-b+\tfrac{1}{2};\,a-c+1;\,\tfrac{1}{2}\right)$$

(s,m,k will be taken real unless otherwise stated)

Theorem 1. If

$$(2.1)\qquad f(s)=s\int_0^{\infty}(2st)^{\lambda}\, W_{k,m}\,(2st)a(t)dt$$

converges for $s>0$, then for any γ, provided that Re $(\lambda+\gamma\pm m+\frac{3}{2})>0$ and any constant A

$$(2.2)\qquad \overline{\lim_{s\to\infty}}\left|s^{\gamma} f(s)-A\right|\leqslant \overline{\lim_{t\to 0+}}\left|\frac{a(t)Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\quad t^{\gamma}}-A\right|$$

$$(2.3)\qquad \overline{\lim_{s\to 0+}}\left|s^{\gamma} f(s)-A\right|\leqslant \overline{\lim_{t\to\infty}}\left|\frac{a(t)Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\quad t^{\gamma}}-A\right|$$

Proof: By using the result of Slater [4]

$$(2.4)\qquad \int_0^{\infty} e^{-st}\, t^{\lambda-1}\, W_{k,m}\,(t)dt=\frac{\Gamma(\lambda+m+\frac{1}{2})\Gamma(\lambda-m+\frac{1}{2})}{(\lambda-k+1)}$$

$$\times\, {}_2F_1(\lambda+m+\tfrac{1}{2},\ \lambda-m+\tfrac{1}{2};\ \lambda-k+1;\ \tfrac{1}{2}-s)$$

Re $(s+\frac{1}{2})>0$ and Re $(\lambda\pm m+\frac{1}{2})>0$

we have

$$(2.5)\qquad \int_0^{\infty}(2st)^{p-1}\, W_{k,m}\,(2st)\ d\,(2st)=\frac{\Gamma(p+m+\frac{1}{2})\ \Gamma(p-m+\frac{1}{2})}{\Gamma(p-k+1)}$$

$$\times\, {}_2F_1\,(p+m+\tfrac{1}{2},\, p-m+\tfrac{1}{2};\, p-k+1;\ \tfrac{1}{2})\equiv Q(p,m,k),$$

where Re $(p\pm m+\frac{1}{2})>0$

Therefore

$$s^{\gamma} f(s)-A=\int_0^{\infty} s^{\gamma+1}(2st)^{\lambda}\ W_{k,m}(2st)a(t)dt-A$$

$$=\int_0^{\infty}(2st)^{\lambda+\gamma}\ W_{k,m}(2st).\,2^{-(\gamma+1)}\,t^{-\gamma}a(t)d(2st)-A$$

Therefore

$$2.6)\qquad |\,s^{\gamma} f(s)-A\,|\leqslant\frac{1}{Q(\lambda+\gamma+1,m,k)}\int_0^{\infty}(2st)^{\lambda+\gamma}W_{k,m}\ (2st)$$

$$\times\left|\frac{a(t)Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\quad t^{\gamma}}-A\right| d\,(2st),$$

where Re $(\lambda+\gamma\pm m+\frac{3}{2})>0$

$$=\frac{1}{Q\,(\lambda+\gamma+1,m,k)}\int_0^{T} 2st)\ )^{\lambda+\gamma}\ W_{k,m}(2st)\left|\frac{a(t)Q(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\quad t^{\gamma}}-A\right|d(2st)$$

$$+\int_{T}^{\infty} s^{\gamma+1}(2st)^{\lambda}\, W_{k,m}(2st)\left|\, a(t)-\frac{At^{\gamma}\, 2^{\gamma+1}}{Q\,(\lambda+\gamma+1,m,k)}\right. dt$$

$$=I_1+I_2$$

But $I_1\leqslant \dfrac{1}{Q\,(\lambda+\gamma+1,m,k)}\times \underset{0\leqslant t\leqslant T}{\text{u. b.}}\left|\dfrac{a(t)Q\,(\lambda+\gamma+1,m\ k)}{2^{\gamma+1}\ t^{\gamma}}-A\right|$

$$\times\int_{0}^{\infty}(2st)^{\lambda+\gamma}\, W_{k,m}(2st)d(2st)$$

$$=\underset{0\leqslant t\leqslant T}{\text{u.b.}}\left|\frac{a(t)Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\ t^{\gamma}}-A\right|$$

For I_2, we observe that on account of convergence [2] of the integral (2.1) for $s>0$, we can, for any positive ε, find a constant M such that

$$\left|\, a(t)-\frac{A\; 2^{\gamma+1}\ t^{\gamma}}{Q\,(\lambda+\gamma+1,m,k)}\right| \angle M e^{\varepsilon t}\ t^{-\lambda-k} \qquad (0\leqslant t<\infty)$$

Also we know that

$$W_{k,m}\,(x)=e^{-\frac{1}{2}x}\ x^{m+\frac{1}{2}}\Psi(\tfrac{1}{2}+m-k,\ 1+2m,x),$$

where Ψ denotes Tricomi's confluent hypergeometric function given by the relation

$$\Psi(a,c,x)=\frac{\Gamma(1-c)}{\Gamma(1+a-c)}\ {}_1F_1\ (a;c;x)+\frac{\Gamma(c-1)}{\Gamma(a)}\ x^{1-c}\ {}_1F_1\ (1+a-c;2-c;x)$$

Hence

$$I_2\leqslant M\ s^{\gamma+\lambda+k+1}\int_{T}^{\infty}(2st)^{m-k+\frac{1}{2}}\ \Psi(\tfrac{1}{2}+m-k;1+2m;2st)\ e^{-(s-\varepsilon)t}\,dt$$

$$=M\ s^{\gamma+\lambda+k+1}\ e^{-T(s-\varepsilon)}\int_{0}^{\infty}(2st+2sT)^{m-k+\frac{1}{2}}\ \Psi(\tfrac{1}{2}+m-k;\ 1+2m;\ 2st+2sT)$$

$$\times e^{-(s-\varepsilon)t}\,dt$$

$$=M_1\ s^{\lambda+\gamma+k+1}\ e^{-T(s-\varepsilon)},$$

because the integral on the right is convergent for all values of s and T.

Thus $\lim\limits_{s\to\infty} I_2=0$, and we get

$$\overline{\lim_{s\to\infty}}\left|\, s^{\gamma} f\,(s)-A\,\right|\leqslant \underset{0\leqslant t\leqslant T}{\text{u.b.}}\left|\frac{a(t)Q\ (\lambda+\gamma+1,m,k)}{2^{\gamma+1}\ t^{\gamma}}-A\right|$$

The left-hand side being independent of T, we allow T to approach zero and obtain

$$\overline{\lim_{s\to\infty}}\left|\, s^{\gamma} f\,(s)-A\,\right|\leqslant \overline{\lim_{t\to 0+}}\left|\frac{a(t)Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\ t^{\gamma}}-A\right|$$

We have thus established (2.2). Proceeding on similar lines we now prove (2.3).

Result (2.6) can also be written as

$$\left| s^{\gamma} f(s) - A \right| \leqslant s^{\gamma+1} \int_0^T (2st)^{\lambda}\, W_{k,m}\,(2st) \left| \alpha(t) - \frac{A t^{\gamma}\; 2^{\gamma+1}}{Q\,(\lambda+\gamma+1,m,k)} \right| dt$$

$$+\frac{1}{Q\,(\lambda+\gamma+1,m,k)} \int_T^{\infty} (2st)^{\lambda+\gamma}\, W_{k,m}\,(2st) \left| \frac{\alpha(t)\,Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\;t^{\gamma}} - A \right| d(2st)$$

The first integral on the right can be proved to approach zero as $s \to 0$ just as we proved for I_2 above when $s \to \infty$

Hence

$$\overline{\lim_{s\to 0+}} \left| s^{\gamma} f(s) - A \right| \leqslant \underset{T \leqslant t \angle \infty}{\text{u.b.}} \left| \frac{\alpha(t)\,Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\;t^{\gamma}} - A \right|$$

$$\times \frac{1}{Q\,(\lambda+\gamma+1,m,k)} \int_0^{\infty} (2st)^{\lambda+\gamma}\, W_{k,m}\,(2st)\,d(2st)$$

$$= \underset{T \leqslant t < \infty}{\text{u.b.}} \left| \frac{\alpha(t)\,Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\;t^{\gamma}} - A \right|$$

Now the left hand side of the inequality is independent of T, we can make T approach infinity.

Therefore

$$\overline{\lim_{s\to 0+}} \left| s^{\gamma} f(s) - A \right| \leqslant \overline{\lim_{t\to\infty}} \left| \frac{\alpha(t)\,Q\,(\lambda+\gamma+1,m,k)}{2^{\gamma+1}\;t^{\gamma}} - A \right|$$

The theorem is thus completely proved.

Verification : If in this theorem we put $\lambda = -\frac{1}{4}$, $m = \frac{1}{4}$, $k = \frac{1}{4}$

$$f(s) = s \int_0^{\infty} e^{-st}\, \alpha(t)\; dt = \int_0^{\infty} e^{-st} d\alpha(t)$$

and $Q\,(\lambda+\gamma+1,m,k) = Q\,(\gamma+\frac{3}{4},\frac{1}{4},\frac{1}{4})$

$$= \frac{\Gamma(\gamma+\frac{3}{2})\Gamma(\gamma+1)}{\Gamma(\gamma+\frac{3}{2})}\; {}_2F_1\;(\gamma+\tfrac{3}{2},\gamma+1;\gamma+\tfrac{3}{2};\tfrac{1}{2})$$

$$= \Gamma(\gamma+1)\; 2^{\gamma+1}$$

Thus the results (2.2) and (2.3) become

$$\overline{\lim_{s\to\infty}} \left| s^{\gamma} f(s) - A \right| = \overline{\lim_{t\to 0+}} \left| a(t) t^{-\gamma} \Gamma(\gamma+1) - A \right|$$

and

$$\overline{\lim_{s\to 0+}} \left| s^{\gamma} f(s) - A \right| = \overline{\lim_{t\to\infty}} \left| a(t) t^{-\gamma} \Gamma(\gamma+1) - A \right|$$

which are the corresponding results for ordinary Laplace transform [7]

Corollary. If for some number γ, such that $\lambda+\gamma\pm m+\frac{3}{2}>0$

$$a(t) \sim A\left(\frac{2^{\gamma+1}\ t^{\gamma}}{Q(\lambda+\gamma+1,m,k)}\right) \qquad \begin{cases} t\to 0+ \\ t\to\infty \end{cases}$$

then

$$f(s) \sim \frac{A}{s^{\gamma}} \qquad \begin{cases} s\to\infty \\ s\to 0+ \end{cases}$$

If $A=0$, we have

$$a(t)=o\,(t^{\gamma})$$

$$f(s)=o(s^{-\gamma})$$

In particular the existence of $a(\infty)$ implies $f(0+)=\frac{1}{2}Q(\lambda+1,m,k) \times a(\infty)$. Also $f(\infty)=\frac{1}{2}Q(\lambda+1,m,k)a(0+)$.

TAUBERIAN THEOREM

3. We observe that due to the property $W_{k,m}(x)=W_{k,-m}(x)$, our kernel "$(2st)^{\lambda}\ W_{k,m}(2st)$" remains unchanged by changing the sign of m. Hence if a particular theorem is true for $m<0$, it will equally be true for $m>0$, only if we change the sign of m throughout the theorem.

Lemma For $m\geqslant 0$ and $x>0$

$$\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)} - x^{m-\frac{1}{2}}\ W_{k,m}(x) \leqslant \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{kx}{1-2m}$$

Proof: Consider the function—

$$F(x) \equiv \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)} - x^{m-\frac{1}{2}}\ W_{k,m}(x) - \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{kx}{1-2m}$$

For $m>0$, $F(0)=0$ and $F'(0)=0$. Again because $F''(0)<0$, the maximum of $F(x)$ is at $x=0$ and since $F(x)$ vanishes at this point its value must be less than or equal to zero. Thus the Lemma is proved.

We note that if we put $m=\frac{1}{4}$ and $k=\frac{1}{4}$, the inequality of the Lemma reduces to the well known inequality

$$1-e^{-\frac{1}{2}x} \leqslant \frac{1}{2}x,\ x>0$$

Theorem 2 (*a*) If $a(t)$ belongs to L in $(0, R)$ for every R and if the integral

$$(3.1)\quad f(s)=\int_0^{\infty}(2st)^{\lambda}\,W_{k,m}(2st)\,a(t)dt$$

converges for $s>0$ and $m>0$, then the conditions

$$(i)\ \lim_{s\to 0+}\left(\frac{f(s)}{s^{\lambda-m+\frac{1}{2}}}\right)=A \text{ and } (ii)\ a(t)=o\left(\frac{1}{t^{\lambda-m+3/2}}\right)\ (t\to\infty)$$

imply

$$\left\{\frac{f(0+)}{s^{\lambda-m+\frac{1}{2}}}\right\}\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\int_0^{\infty}(2t)^{\lambda-m+\frac{1}{2}}\,a(t)\,dt=A$$

Proof. Under the hypothesis (*ii*) of the theorem we have

$$(3.2)\quad \frac{1}{t}\int_0^{t}|a(u)|\,u^{\lambda-m+\frac{3}{2}}\,du=o\,(1)\qquad (t\to\infty)$$

Now

$$\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\int_0^{t}u^{\lambda-m+\frac{1}{2}}\,a(u)du-t^{\lambda-m+\frac{1}{2}}\int_0^{\infty}\left(\frac{u}{t}\right)^{\lambda}W_{k,m}\left(\frac{u}{t}\right)\,a(u)du$$

$$=\int_0^{t}u^{\lambda-m+\frac{1}{2}}\,a(u)\left\{\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}-\left(\frac{u}{t}\right)^{m-\frac{1}{2}}W_{k,m}\left(\frac{u}{t}\right)\right\}du$$

$$-\int_t^{\infty}t^{\lambda-m+\frac{1}{2}}\left(\frac{u}{t}\right)^{\lambda}W_{k,m}\left(\frac{u}{t}\right)a(u)\,du.$$

$$=I_1+I_2$$

$$|\,I_1\,|\leqslant\frac{\Gamma(2m)k}{\Gamma(\frac{1}{2}+m-k)(1-2m)}\ \frac{1}{t}\int_0^{t}u^{\lambda-m+\frac{3}{2}}\,|\,a(u)\,|\,du,$$ by the Lemma

and this reduces to zero as $t\to\infty$ by (3.2).

And

$$|\,I_2\,|\leqslant\underset{t\leqslant u<\infty}{\text{u.b.}}\left|a(u)\,u^{\lambda-m+\frac{3}{2}}\right|\int_t^{\infty}\left|\frac{1}{u}\left(\frac{u}{t}\right)^{m-\frac{1}{2}}W_{k,m}\left(\frac{u}{t}\right)\right|du$$

But $\displaystyle\int_t^{\infty}\left|\frac{1}{u}\left(\frac{u}{t}\right)^{m-\frac{1}{2}}W_{k,m}\left(\frac{u}{t}\right)\right|du=\int_1^{\infty}\left|\frac{1}{v}\,v^{m-\frac{1}{2}}\,W_{k,m}(v)\right|dv$

$$\leqslant\int_1^{\infty}\left|v^{m-\frac{1}{2}}\,W_{k,m}(v)\right|dv$$

$$\leqslant \int_0^\infty \left| v^{m-\frac12}\, W_{k,m}(v) \right| dv$$

and this last integral is convergent by (2.4)

Therefore

$$\left|I_2\right| \leqslant \underset{t\leqslant u<\infty}{\text{u.b}} \left| .a(u)\, u^{\lambda-m+\frac32} \right| \times a \text{ finite quantity}$$

Hence taking the limit as $u\to\infty$ and using the hypothesis (*ii*), $I_2 \,|\to 0$

Therefore

$$\lim_{t\to\infty} \left[\frac{\Gamma(2m)}{\Gamma(m-k+\frac12)} \int_0^t u^{\lambda-m+\frac12}\, a(u)\, du - t^{\lambda-m+\frac12} \int_0^\infty \left(\frac{u}{t}\right)^\lambda W_{k,m}\left(\frac{u}{t}\right) a(u)\, du \right] = 0$$

$$\therefore \frac{\Gamma(2m)}{\Gamma(\frac12+m-k)} \int_0^\infty (u)^{\lambda-m+\frac12}\, a(u)\, du$$

$$= \lim_{s\to 0+} \frac{1}{(2s)^{\lambda-m+\frac12}} \int_0^\infty (2su)^\lambda\, W_{k,m}(2su)\; a(u)\, du$$

Thus the theorem is proved.

Theorem 2 (*b*) If $a(t)$ belongs to L in (0, R) for every R and if the integral (3.1) converges for $s>0$ and $m<0$, then the conditions

(*i*) $\lim_{s\to 0+} \left\{ \frac{f(s)}{s^{\lambda+m+\frac12}} \right\} = A$ and (*ii*) $a(t) = o\left(\frac{1}{t^{\gamma+m+\frac32}} \right)$ $(t\to\infty)$

imply

$$\left\{ \frac{f(0+)}{s^{\lambda+m+\frac12}} \right\} = \frac{\Gamma(-2m)}{\Gamma(\frac12-m-k)} \int_0^\infty (2t)^{\lambda+m+\frac12}\, a(t)\, dt = A$$

The proof is similar

Verification—If we put $\lambda=-\frac14$, $k=\frac14$ and $m=\frac14$ and $-\frac14$ respectively, the theorems 2 (*a*) and 2 (*b*) reduce to the corresponding theorems for ordinary Laplace transform.

4. A more general result is contained in the following theorem:—

Theorem 3 (*a*). Let

$$(4.1) \qquad f(s) = \int_0^\infty (2st)^\lambda\, W_{k,m}(2st)\, da(t)$$

Converge for $s>0$, $m>0$, and let

$$(4.2)\quad \lim_{s\to 0+}\left\{\frac{f(s)}{s^{\lambda-m+\frac{1}{2}}}\right\}=A$$

then

$$(4.3)\quad \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\int_0^{\infty}(2t)^{\lambda-m+\frac{1}{2}}\,d\alpha(t)\ \text{ or }\ \lim_{t\to\infty}\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}$$

$$\times\left\{(2t)^{\lambda-m+\frac{1}{2}}\alpha(t)-2(\lambda-m+\tfrac{1}{2}\int_0^t(2u)^{\lambda-m-\frac{1}{2}}\,\alpha(u)\,du\right\}=A$$

if and only if

$$(4.4)\quad \beta(t)=\int_0^t u^{\lambda-m+\frac{3}{2}}\,d\alpha(u)=o(t)\qquad (t\to\infty)$$

provided Re $(\lambda-m+\frac{1}{2})>0$, $\alpha(t)$ being a normalized function.

[Here we observe that if

$$\alpha(t)=\int_0^t a(u)du$$

then $a(t)=o\left(\frac{1}{t^{\lambda-m+\frac{3}{2}}}\right)$ $(t\to\infty)$ implies that

$$\beta(t)\equiv\int_0^t u^{\lambda-m+\frac{3}{2}}\,d\alpha(u)=\int_0^t u^{\lambda-m+\frac{3}{2}}\,a(u)du=o(t)\qquad (t\to\infty)$$

Thus the Theorem 2(a) is included in this theorem.]

Proof. We shall assume here without loss of generality that $A=0$. First let us suppose that (4.3) holds and prove (4.4). This is obvious, because

$$\beta(t)=\int_0^t u^{\lambda-m+\frac{3}{2}}\,d\alpha(u)$$

$$=t^{\lambda-m+\frac{3}{2}}\alpha(t)-(\lambda-m+\tfrac{3}{2})\int_0^t u^{\lambda-m+\frac{1}{2}}\,\alpha(u)\,du$$

$$=o(t)\qquad (t\to\infty)$$

Conversely let us assume (4.4) and prove (4.3). Now

$$\int_1^{\infty}(2su)^{\lambda}\,W_{k,m}(2su)\,d\alpha(u)=\int_1^{\infty}\frac{(2su)^{\lambda}\,W_{k,m}(2su)}{u^{\lambda-m+\frac{3}{2}}}\,d\beta(u)$$

$$=-(2s)^{\lambda}\,W_{k,m}(2s)\,\beta(1)-2s\int_1^{\infty}(2su)^{\lambda-1}\left\{(k+\lambda-su)\,W_{k,m}(2su)\right.$$

$$-(m^2-(k-\tfrac{1}{2})^2)\ W_{k-1,m}\ (2su)\Big\}\frac{\beta(u)}{u^{\lambda-m+\frac{3}{2}}}\,du$$

$$+(\lambda-m+\tfrac{3}{2})\int_1^{\infty}(2su)^{\lambda}\ W_{k,m}\ (2su)\frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\,du,$$

$$\Big[\text{using } \frac{d}{dx}\{x^{\lambda}\ W_{k,m}(x)\}=x^{\lambda-1}\{(k+\lambda-\tfrac{1}{2}x)\ W_{k,m}\ (x) -(m^2-(k-\tfrac{1}{2})^2)W_{k-1,m}(x)\ \}\Big]$$

whence we get,

$$\int_1^{\infty}(2su)^{\lambda}\ W_{k,m}(2su)d\alpha(u)=-(2s)^{\lambda}\ W_{k,m}\ (2s)\ \beta(1)$$

$$(4.5)\quad\left\{\begin{aligned}&+s\int_1^{\infty}(2su)^{\lambda}\ W_{k,m}(2su)\ \frac{\beta(u)}{u^{\lambda-m+\frac{3}{2}}}\,du\\&+(\tfrac{3}{2}-k-m)\int_1^{\infty}(2su)^{\lambda}\ W_{k,m}(2su)\ \frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\,du\\&+(m+k-\tfrac{1}{2})\ (m-k+\tfrac{1}{2})\int_1^{\infty}(2su)^{\lambda}\ W_{k-1,m}\ (2su)\ \frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\,du\end{aligned}\right.$$

By using corollary of theorem (1) we have

$$\lim_{s\to 0}\ s\int_1^{\infty}(2su)^{\lambda}\ W_{k,m}(2su)\ \frac{\beta(u)}{u^{\lambda-m+\frac{3}{2}}}\,du=o\ (s^{\lambda-m+\frac{1}{2}})=0,$$

because Re $(\lambda-m+\frac{1}{2})>0$

By (4.2)
$$\lim_{s\to 0}\frac{1}{s^{\lambda-m+\frac{1}{2}}}\int_1^{\infty}(2su)^{\lambda}\ W_{k,m}(2su)\ d\alpha(u)$$

$$=-\lim_{s\to 0}\frac{1}{s^{\lambda-m+\frac{1}{2}}}\int_0^{1}(2su)^{\lambda}\ W_{k,m}(2su)d\alpha(u)$$

$$=-\lim_{s\to 0+}\Big(\frac{1}{s^{\lambda-m+\frac{1}{2}}}\Big)\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ (2s)^{\lambda-m+\frac{1}{2}}\int_0^{1}u^{\lambda-m+\frac{1}{2}}\ d\,\alpha(u),$$

since for $m>0$,

$$\lim_{s\to 0+}\Big\{W_{k,m}\ (2su)\Big\}=\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ (2su)^{-m+\frac{1}{2}}\quad(s\to 0)$$

Thus we get

$$\lim_{s\to 0+}\int_{1}^{\infty}(2su)^{\lambda}.\,W_{k,m}\,(2su)\;da(u)$$

$$=-\lim_{s\to 0+}\;\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\;(2s)^{\lambda-m+\frac{1}{2}}\left\{a(1)-(\lambda-m+\tfrac{1}{2})\times\int_{0}^{1}u^{\lambda-m-\frac{1}{2}}\,a(u)\;du\right\}$$

consequently (4.5) gives

$$\lim_{s\to 0+}\Bigg[(\tfrac{3}{2}-k-m)\int_{1}^{\infty}(2su)^{\lambda}\;W_{k,m}\;(2su)\frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\;du$$

$$+(m+k-\tfrac{1}{2})\;(m-k+\tfrac{1}{2})\int_{1}^{\infty}(2su)^{\lambda}\;W_{k-1,m}(2su)\;\frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\;du\;\Bigg]$$

$$=\lim_{s\to 0+}\Bigg[(2s)^{\lambda}\;W_{k,m}(2s)\;\beta(1)-\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\;(2s)^{\lambda-m+\frac{1}{2}}\times\left\{\alpha(1)-(\lambda-m+\tfrac{1}{2})\int_{0}^{1}u^{\lambda-m-\frac{1}{2}}\;\alpha(u)\;du\right\}\Bigg]$$

But on using the well known recurrence formula—

$$W_{k,m}\;(x)=x^{\frac{1}{2}}\;W_{k-\frac{1}{2},\;m-\frac{1}{2}}\;(x)+(\tfrac{1}{2}-k+m)\;W_{k-1,m}(x)$$

we obtain

$$\lim_{s\to 0+}\;(m-k+\tfrac{1}{2})\;W_{k-1,m}\;(2su)=\lim_{s\to 0+}\;W_{k,m}\;(2su)$$

Therefore

$$\lim_{s\to 0+}\Bigg[\int_{1}^{\infty}(2su)^{\lambda}\;W_{k,m}\;(2su)\frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\;du\;\Bigg]$$

$$=\lim_{s\to 0+}\Bigg[\;\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\;(2s)^{\lambda-m+\frac{1}{2}}\left\{\;\beta(1)-\alpha(1)+(\lambda-m+\tfrac{1}{2})\times\int_{0}^{1}u^{\lambda-m-\frac{1}{2}}\;\alpha(u)\;du\right\}\Bigg]$$

whence

$$\lim_{s\to 0+}\Bigg[\frac{1}{s^{\lambda-m+\frac{1}{2}}}\int_{1}^{\infty}(2su)^{\lambda}\;W_{k,m}\;(2su)\frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\;du\;\Bigg]$$

$$=\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ 2^{\lambda-m+\frac{1}{2}}\left\{\beta(1)-\alpha(1)+(\lambda-m+\tfrac{1}{2})\int_0^1 u^{\lambda-m-\frac{1}{2}}\,\alpha(u)\,du\right\}$$

But by (4.4), $\dfrac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}=o\left(\dfrac{1}{u^{\lambda-m+\frac{3}{2}}}\right)$ $\qquad (u\rightarrow\infty)$

Hence applying Theorem 2(*a*), we get

$$\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\int_1^\infty (2u)^{\lambda-m+\frac{1}{2}}\ \frac{\beta(v)}{u^{\lambda-m+\frac{5}{2}}}\,du=\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ 2^{\lambda-m+\frac{1}{2}}$$

$$\left\{\beta(1)-\alpha(1)+(\lambda-m+\tfrac{1}{2})\int_0^1 u^{\lambda-m-\frac{1}{2}}\,\alpha(u)du\right\} \tag{4.6}$$

$$\text{But }\int_1^\infty u^{\lambda-m+\frac{1}{2}}\,\frac{\beta(u)}{u^{\lambda-m+\frac{5}{2}}}\,du=\int_1^\infty \frac{\beta(u)}{u^2}\,du$$

$$=\beta(1)+\int_1^\infty \frac{1}{u}\,d\,\beta(u),\ \left[\text{ since } \frac{\beta(u)}{u}=o(1), \qquad (u\rightarrow\infty)\ \right]$$

$$=\beta(1)+\int_1^\infty u^{\lambda-m+\frac{1}{2}}\,d\alpha(u)$$

$$=\beta(1)+\lim_{t\rightarrow\infty}\ t^{\lambda-m+\frac{1}{2}}\,\alpha(t)-\alpha(1)-(\lambda-m+\tfrac{1}{2})\int_1^\infty u^{\lambda-m-\frac{1}{2}}\alpha(u)\,du$$

on using the above result, (4.6) reduces to

$$\lim_{t\rightarrow\infty}\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\left\{(2t)^{\lambda-m+\frac{1}{2}}\,\alpha(t)-2(\lambda-m+\tfrac{1}{2})\int_0^t (2u)^{\lambda-m-\frac{1}{2}}\,\alpha(u)\,du\right\}=0$$

Thus the theorem is proved.

Theorem 3(*b*) If (4.1) converges for $s>0$ and $m<0$, and if

$$\lim_{s\rightarrow 0+}\left(\frac{f(s)}{s^{\lambda+m+\frac{1}{2}}}\right)=A,$$

then

$$\lim_{t\rightarrow\infty}\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\left\{(2t)^{\lambda+m+\frac{1}{2}}\,\alpha(t)-2(\lambda+m+\tfrac{1}{2})\int_0^t (2u)^{\lambda+m-\frac{1}{2}}\,\alpha(u)du\right\}=A$$

if and only if

$$\beta(t)=\int_0^t u^{\lambda+m+\frac{3}{2}}\,d\alpha(u)=o(t) \qquad (t\rightarrow\infty),$$

provided Re $(\lambda+m+\frac{1}{2})>0$, $a(t)$ being a normalized function. Proof is quite similar.

Verification. If we put $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\frac{1}{4}$ and $-\frac{1}{4}$ respectively, the theorems 3(*a*) and 3(*b*) reduce to the corresponding theorem for ordinary Laplace transform.

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EFFECT OF GIBBERELLIC ACID TREATMENT OF FRESHLY HARVESTED POTATO TUBERS ON SPROUT EMERGENCE, PLANT GROWTH AND TUBER PRODUCTION

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In the plains of North India some growers take two crops of potato in the same growing season from the same field by plantings short duration varieties like Up-to Date. The first crop is harvested in early December and the second is planted in the same month after the first. However, due to dormancy which may extend upto three months, freshly harvested potato tubers from the previous crop can not be used as planting stock for the second. For this, either the seed tubers from the previous year's harvest have to be stored in cold store or have to be imported from the hills. This increases the seed cost considerably and does not encourage the practice to be followed widely.

Ethylene chlorohydrin was reported by Denny (1926) to be very effective in breaking the dormancy of potato but due to deadly poisonous nature of the chemical it did not become popular with the growers. If some how a convenient and safe method, which can be adopted commercially by growers for reducing the rest period of potato tubers, is developed, the seed cost may be reduced to a great extent. Rappaport *et al* (1957) from California reported that gibberellic acid is quite effective in breaking the dormancy of freshly harvested potato tubers. Lippert *et al* (1958) were able to induce sprouting of potato tubers by foliar application of gibberellin. Rappaport and Singh (1961) evaluating the practical utility of gibberellins in vegetable production suggested for further investigations for making it practically adoptable in potato production.

This report deals with sprout emergence, plant growth and tuber production from freshly harvested potato tubers as influenced by different concentrations of gibberellic acid and types of planting material.

MATERIAL AND METHODS

The experiment was conducted during the winter season of 1961-62 at the B. R. College, Bichpuri, Agra. Two types of freshly harvested potato tubers of up-to-date variety, *i.e.*, whole and cut, were dipped in aqueous solution containing 0,5,10,20,40 and 80 ppm of 75% potassium salt of gibberellic acid (GA) for 5 minutes on December 25, 1961. The size of whole and cut seed pieces was kept almost uniform. The treated tubers were kept at room temperature over night and planted in the field on 26th December, 1961. There were, thus, 12 treatment combinations which were replicated four times in a randomised block design.

The planting was done in single row plots. The rows in the net plot were 9 ft. long and were spaced 1·5 ft. apart. The tubers were planted 9″ apart on the ridge. The crop was harvested on April 30, 1962.

EXPERIMENTAL RESULTS

Time taken for the start of sprout emergence after planting.—The effects of concentrations of GA, types of planting tuber and their interaction on the time taken for the start of sprout emergence after planting are summarized in table 1. The treatment of tubers with GA before planting resulted in a significant reduction in the time required for sprout emergence over control. The concentrations of GA and the time taken for the start of sprout emergence after planting were inversely related. As the concentration increased there was a corresponding reduction in the time taken for the start of sprout emergence. However, these reductions were not significant except that induced by 80 ppm which was significantly more than those caused by 5 and 10 ppm.

TABLE 1

The effect of concentration of GA, type of tubers planted and their interaction on the time taken for the start of sprout emergence.

Concentration of GA	No. of weeks required for sprout emergence			C.D. for concentration at 5%
	Whole tuber planted	Cut tuber planted	Average	
0 ppm	10·5	8·3	9·4	0·90
5 ppm	10·0	5·3	7 6	
10 ppm	9·3	5·3	7·3	
20 ppm	9·0	5·0	7·0	
40 ppm	9·0	5·0	7·0	
80 ppm	7·8	5·0	6·4	
Average	9·3	5·6		
C.D. for type of tubers planted at	5%	1·64		
C.D. for interaction at	5%	1·27		

Sprout emergence occurred earlier in cut tubers than in whole ones, the differences being significant under all treatments including control.

The concentrations of GA exhibited an interesting interaction with the types of tuber planted. Cut tubers responded better to the application of GA than whole tubers in inducing early sprout emergence of resting potatoes. Even 5 ppm GA brought about a significant reduction in the time required for sprout emergence in cut tubers as compared to control but in whole tubers even upto 10 ppm there was no significant improvement over untreated ones. In whole tubers earliest sprout emergence resulted from highest concentration of GA, *i.e.*, 80 ppm whereas in cut tubers the concentrations of GA beyond 5 ppm did not show any additional advantage. It may also be pointed out that merely the operation of cutting the tubers before planting brought about a significant reduction in the time taken for the start of sprout emergence after planting.

Progress of sprout emergence—Number of sprouts emerged in each plot were recorded at weekly intervals from the time of planting till harvest. The data are shown graphically in Fig. 1 and 2. The stand of plants was markedly higher in tubers treated with GA than in untreated ones at all the stages upto harvest (Fig. 1). Sprout emergence in GA treated tubers continued to increase under almost all the concentrations with a steady and more rapid rate upto 12 to 13 weeks after planting after which the rate of increase slowed down, whereas in untreated tubers this increase continued with more or less the same speed upto 1 week before harvest. However, different concentrations of GA did not produce much variation in per cent sprout emergence at subsequent stages after planting.

It would be appropriate to point out here that one should not be misled by comparing the variations caused by different concentrations of GA in the time taken for the start of sprout emergence (Table 1) with figure 1 in which curves for progress of sprout emergence as influenced by different concentrations of GA start from one point indicating that there was no difference in the time for the start of sprout emergence due to the effect of concentrations of GA. Time required for start of sprout emergence is based on averages of all replications in each treatment.

From Fig. 2 it is clear that 7 weeks after planting, when whole tubers also started sprouting, the percentage of sprout emergence in cut tubers was much higher than in whole tubers, there being a difference of 36·1%. This difference in the per cent sprout emergence of cut and whole tubers was more or less maintained upto 15 weeks after planting. In cut tubers the sprout emergence was definitely more rapid and continued to increase with a steady rate from 5 to 11 weeks after planting after which the rate of increase in sprout emergence slowed down. In whole tubers the sprout emergence continued to increase with a steady rate from 7 to 16 weeks after planting. It is thus seen that the period of rapid sprout emergence in cut tubers was 6 weeks whereas in whole tubers it was 9 weeks, *i.e.*, 3 weeks more than in cut tubers. The superiority gained by cut tubers over whole tubers in the beginning was maintained upto harvest.

Per cent stand at 12 weeks after planting—The potato tubers of cultivated varieties after harvesting remain in resting condition for about 1-3 months depending on the varietal characteristics. It was, therefore, decided to analyse the plant stand statistically at 12 weeks after planting to see the effect of GA at a stage when even all the untreated tubers were supposed to have sprouted. It would be seen from table 2 that the treatment of freshly harvested potato tubers with 5 ppm GA increased the per cent stand to almost double of the control. This increase was highly significant statistically. Further increase in the concentration upto 20 ppm did not increase the stand significantly over that of 5 ppm. The highest stand was produced by treatment with 40 ppm which was significantly more than those due to 5 and 10 ppm. The treatment with 80 ppm, however, did not bring any improvement over 40 ppm.

TABLE 2

Plant stand at 12 weeks after planting as influenced by concentrations of GA and types of planting tubers.

Treatments	Plant stand (Per cent)	C.D. at 5%
Concentrations of GA		
0 ppm	32·3	
5 ppm	60·4	
10 ppm	63·5	
20 ppm	68·7	17·05
40 ppm	82·9	
80 ppm	81·9	
Types of planting tubers		
Whole tuber	43·4	9·74
Cut tuber	79·9	

Stand of plants recorded 12 weeks after planting in cut tubers was nearly double of that produced by whole tubers, the difference being significant statistically.

Height, number of leaves and spread per plant—Table 3 summarizes the effect of concentrations of GA and types of tubers planted on height, number of leaves and spread per plant at 4 weeks before harvest. The height as measured in the natural position did not vary much at this stage due to treatment with different concentrations of GA. The number of leaves increased with the increase in concentration of GA upto 20 ppm beyond which there was reduction in the number of leaves per plant. All the concentrations of GA produced significantly greater number of leaves per plant than control. The highest number of leaves was produced by the plants grown from tubers treated with 20 ppm GA. All the concentrations of GA significantly increased the spread per plant over control. However, different concentrations of GA did not produce any significant variation in the spread per plant between themselves.

TABLE 3

Height, number of leaves and spread per plant as influenced by concentrations of GA and types of planting tubers at 4 weeks before harvest.

Treatments	Height of the plant (cm.)	Number of leaves per plant	Spread per plant (cm.)
Concentrations of GA			
0 ppm	27·1	16·5	21·1
5 ppm	29·9	28·2	32·7
10 ppm	30·8	29·1	34·1
20 ppm	33·7	37·5	38·7
40 ppm	29·4	21·0	31·6
80 ppm	30·8	23·3	40·7
C.D. at 5%	N.S.	4·50	8·25
Types of planting tuber			
Whole tuber	29·8	19·0	30·3
Cut tuber	30·8	32·2	37·7
C.D. at 5%	N.S.	2·58	4·86

N.S.=Not significant

The height of plants grown from whole and cut tubers was almost equal at this stage but significantly greater number of leaves and spread per plant were recorded on plants raised from cut tubers than in those grown from whole tuber.

An interesting point with regard to the effect of higher concentrations of GA, *i.e.*, 40 and 80 ppm was that they caused very rapid shoot elongation just after sprout emergence without production of sufficient number of leaves. The leaves that were formed were of pale green colour (Plates 4 and 5). These plants had longer internodes, thinner and fragile stem and, therefore, were trailing on the ground. When both cut as well as whole tubers were treated with lower concentrations of GA, the resulting plants were stocky and developed normally with sufficient number of dark green foliage (Plates 1 to 3).

Fresh weight and number of tubers per plant and average weight per tuber—Fresh weight and number of tubers per plant as well as average weight per tuber as influenced by concentrations of GA and types of planting tuber are given in table 4.

TABLE 4

Fresh weight and number of tubers per plant, and average weight per tuber as affected by concentrations of GA and types of planting tubers at harvest.

Treatments	Fresh weight of tubers per plant (gm.)	Number of tubers per plant	Average weight per tuber (gm.)
Concentrations of GA			
0 ppm	27·0	3·0	9·0
5 ppm	110·2	4·4	25·0
10 ppm	104·3	4·3	24·3
20 ppm	146·1	5·4	27·1
40 ppm	85·0	5·4	15·7
80 ppm	84·6	5·0	16·9
C.D. at 5%	64·89	2·27	...
Types of planting tubers.			
Whole tuber	65·8	3·2	20·6
Cut tuber	112·3	4·7	23·9
C.D. at 5%	46·44	1·31	...

Treatment with lower concentrations of GA produced significant increase in the fresh weight of tubers per plant over control. However, the variation in the fresh weight of tubers per plant caused due to different concentrations of GA was statistically not significant showing thereby that 5 ppm was as effective as higher concentrations of GA.

Only 20 and 40 ppm GA produced a significant increase in the number of tubers per plant over control. The different concentrations of GA between themselves did not produce any significant variation in the number of tubers per plant. All the concentrations of GA produced a marked increase in the average size of tubers over control. There was not much difference in the average weight of tubers resulting from the treatment with 5, 10 and 20 ppm but increasing the concentrations of GA beyond 20 ppm resulted in a considerable drop in the average size of tubers.

The plants grown from cut tubers yielded greater fresh weight and number of tubers per plant with higher average weight per tuber than those raised from whole tubers.

DISCUSSION

The present experiment has clearly indicated that the treatment of cut tubers with 5 ppm GA was very effective in breaking the dormancy of freshly harvested potato tubers and induced sprout emergence 3 weeks earlier than in control. With whole tubers earliest sprout emergence was noted when tubers were treated with 80 ppm. Rappaport, Timm and Lippert (1957) from California reported reduction in the dormant period of freshly harvested tubers of white potatoes by treatment of cut seed pieces with as low as 5 ppm GA. Hemberg (1949) pointed out that the dormancy in newly formed potato tubers is correlated with the appearance of non-auxin chemical growth-inhibitor in the skin of tubers. He further expressed his opinion that such tubers would not sprout immediately under conditions favourable for growth and must wait until the disappearance of the inhibitor which would allow the buds to develop. Smith and Rappaport (1961) showed that the concentration of endogenous gibberellins remained low during the rest period and increased 30 fold as the rest period came to an end. The increase in endogenous gibberellins might have counteracted the effect of chemical growth-inhibitor and made the tuber to sprout. It is just possible that supplementing the low quantity of gibberellins in early period of rest might have produced the same effect and, therefore, the treatment of resting tubers with GA resulted in early sprouting.

The plant growth and tuber production were greatly influenced by treatment of tubers with different concentrations of GA before planting. The variation was more striking in earlier than in later stages of growth. In earlier stages the shoot elongation was more rapid under 40 and 80 ppm as compared with 5 to 20 ppm with the result that the shoots of plants grown from tubers treated with concentrations of GA higher than 20 ppm were spindly, long, weak, with fewer number of leaves and trailed on the ground (Plates 4 and 5). This reduced the height as measured in the natural position. Those in plants treated with 5 to 20 ppm were stocky and had more number of dark green leaves (Plates 1 to 3).

Sachs (1961) reported increased cell division and cell elongation due to GA treatment. This must have been responsible for rapid elongation of shoots which were thin and weak at higher concentrations of GA. Rappaport and others (1958) also considered 5-10 ppm GA most desirable for treatment of resting potatoes to break the dormancy and to get the normal plants. They also observed similar abnormal plants when treated with higher concentrations of GA as reported in the present experiment. The yield per plant by weight and number as well as the size of tubers were highest when tubers were treated with 20 ppm GA before planting but these did not differ significantly when compared with 5 and 10 ppm. Further increase in the concentrations of GA beyond 20 ppm resulted in lower yield of tubers which were of smaller size. Higher yield in GA treated plants may be attributed to higher plant stand, and early start of sprout emergence which resulted in longer period for vegetative growth and ultimately higher yield, greater number as well as larger size of tubers. Under control tubers sprouted very late and started their growth at a time when conditions for tuberization were not favourable. The prevalence of high temperature, during the later stage of the crop when control plants were still in vigorous vegetative growth, would not have been favourable for tuberization due to increased utilization of photo-synthates in respiration and this could have lowered the yield of tubers per plant both by weight and number and could have also reduced the size of individual tubers. Timm, Rappaport, Bishop and Hoyle (1962) also reported increased yield due to the treatment of resting potatoes with GA.

It is interesting to note that even cutting of the tubers resulted in early sprout emergence, higher plant stand and more vegetative growth than the use of whole tubers as planting stock. This provided longer period of vegetative growth under favourable conditions for tuberization which was reflected in larger size of tubers and higher yields per plant.

SUMMARY

Freshly harvested potato tubers, whole as well as cut, of Up-to-Date variety of potato, were treated with six concentrations of gibberellic acid (GA) *i.e.*, 0,5,10,20,40 and 80 ppm and planted in the field on 26th Dec., 1961. Sprout emergence, plant growth and tuber production were studied.

The sprout emergence was earliest when cut tubers were treated with GA. Treatment with 5 ppm resulted in the emergence of sprouts 3 weeks earlier than control. Concentrations of GA higher than 5 ppm did not improve significantly the earliness in sprout emergence in cut tubers.

Plant stand, number of leaves, spread, fresh weight of tubers and number of tubers per plant as well as average weight per tuber were significantly more when freshly harvested tubers treated with GA, were planted than in the case of control. On the whole, concentrations higher than 5 ppm did not improve these characters significantly. Moreover, higher concentrations of 40 and 80 ppm resulted in leggy and weak shoots which reduced the number of leaves, fresh weight of tubers per plant and average weight per tuber considerably.

Planting of freshly harvested cut tubers also reduced the time taken for the start of sprout emergence significantly. Use of cut tubers as planting stock increased significantly the plant stand, number of leaves, spread, fresh weight of tubers and number of tubers per plant as well as average weight per tuber over those resulting from planting of whole tubers.

ACKNOWLEDGEMENT

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Agra for his keen interest and valuable suggestions in the preparation of this paper.

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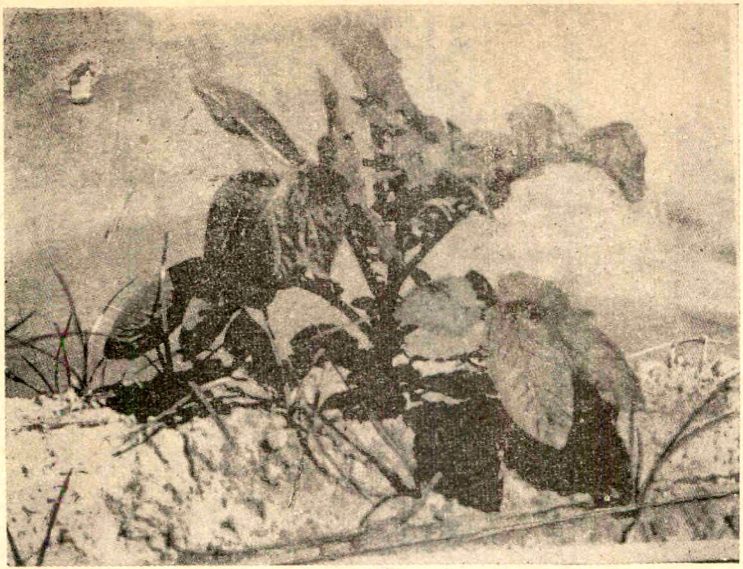

Plate 1. Plants grown from cut tubers treated with 5 ppm GA.

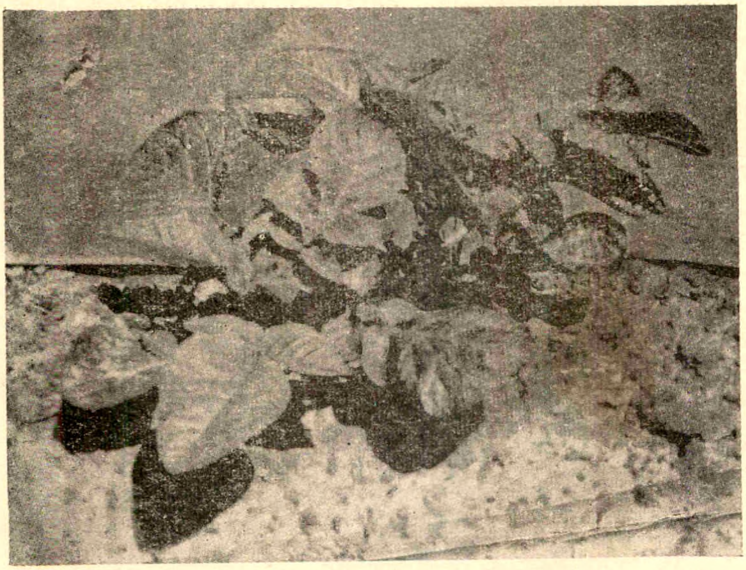

Plate 2. Plants grown from cut tubers treated with 10 ppm GA.

Plate 3. Plants grown from cut tubers treated with 20 ppm,

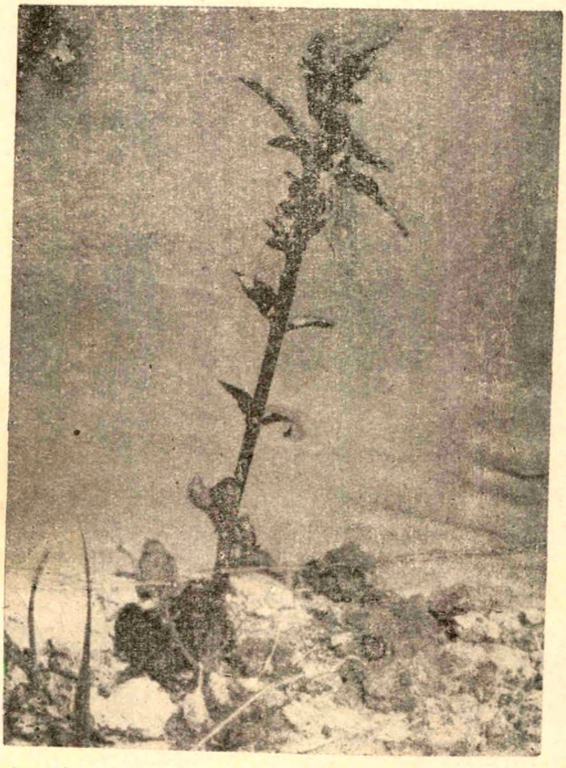

Plate 4. Plants grown from cut tubers treated with 40 ppm G.A.

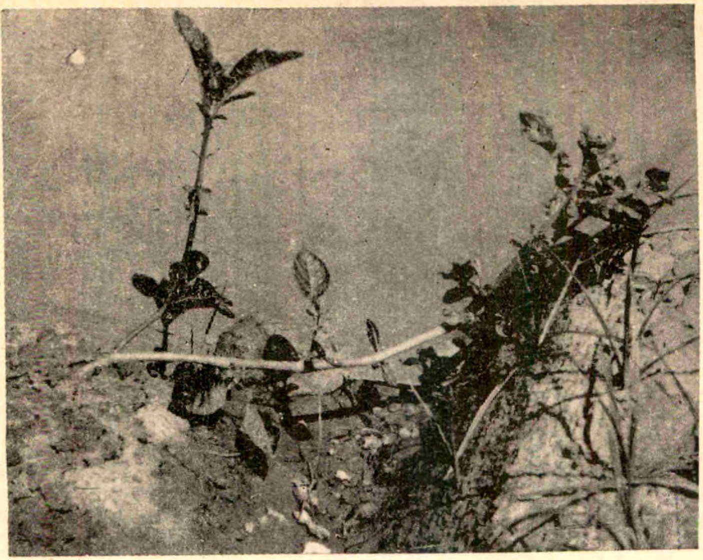

Plate 5. Plants grown from cut tubers treated with 80 ppm GA.

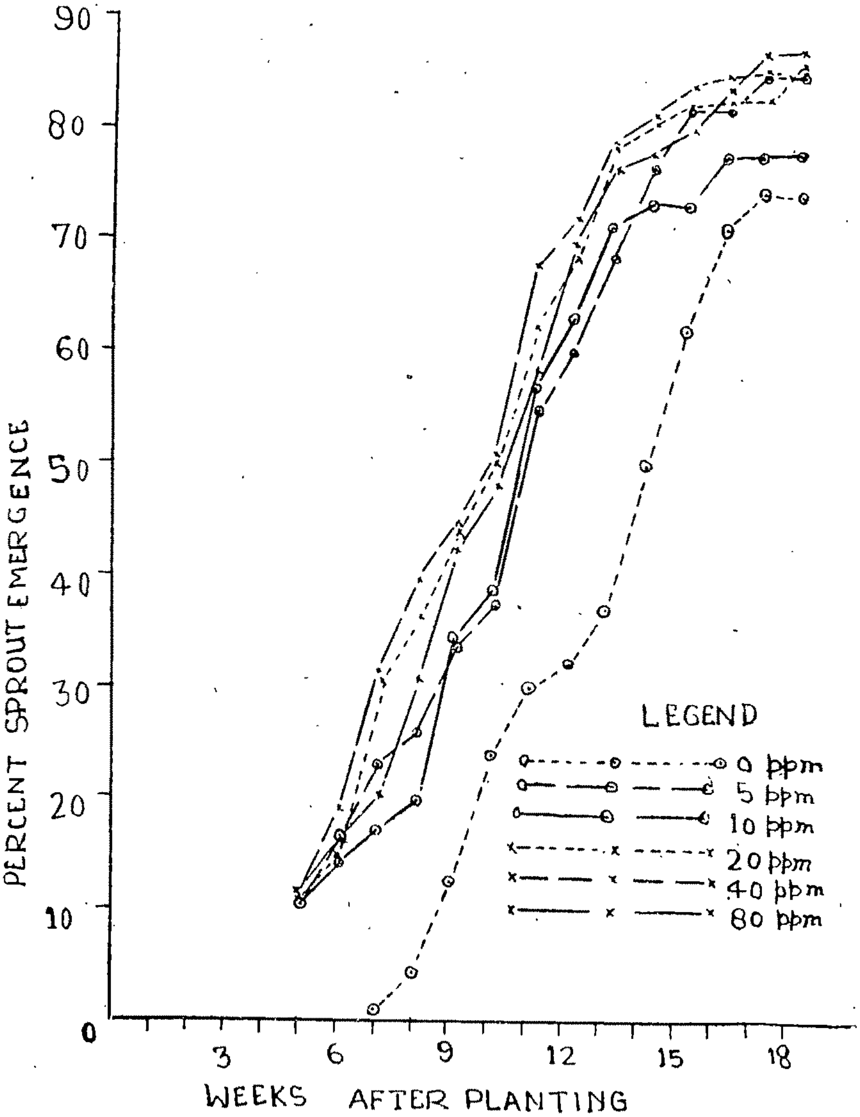

Fig. 1. SPROUT EMERGENCE AS INFLUENCED BY CONCENTRATIONS OF GIBBERELLIC ACID

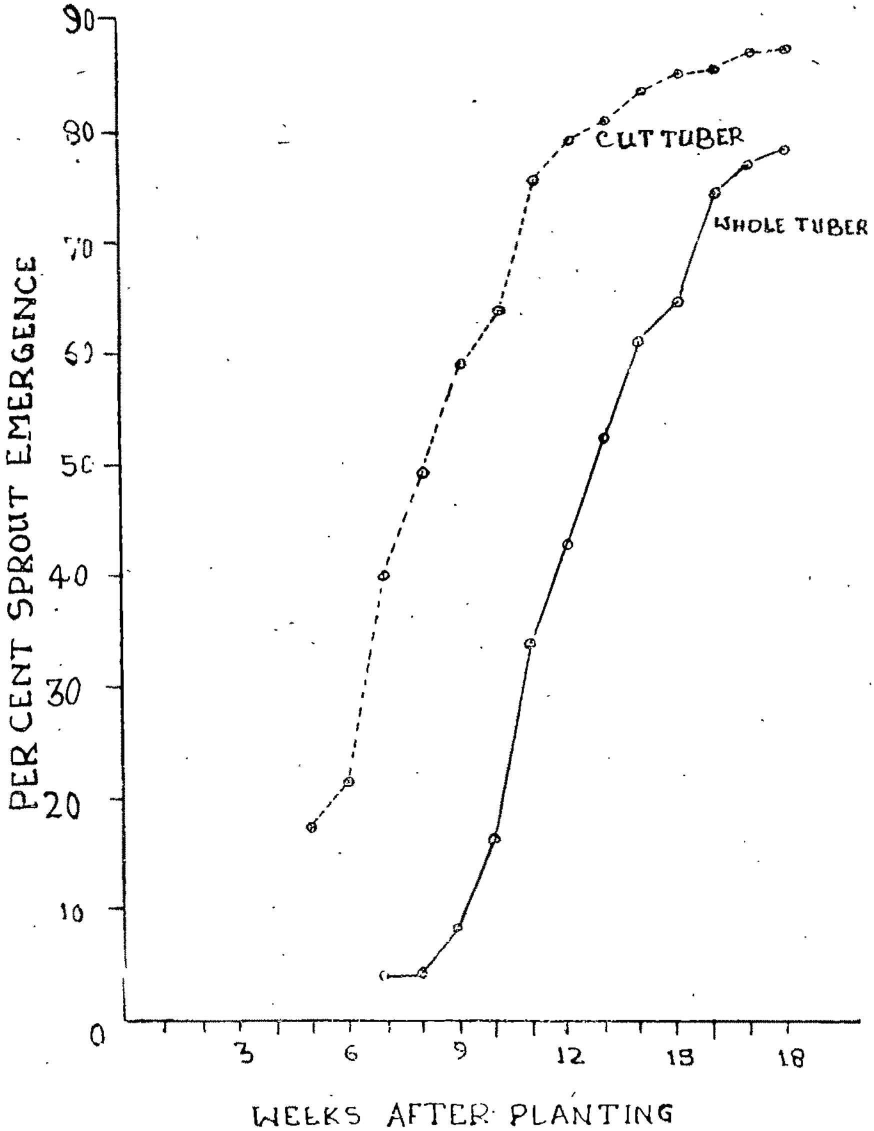

Fig. 2. SPROUT EMERGENCE AS INFLUENCED BY TYPES OF PLANTING TUBER

PHYSICO-CHEMICAL STUDIES ON THE CONDENSATION PRODUCTS OF REYCHLER'S ACID WITH AROMATIC AMINES

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INTRODUCTION

The condensation products of Reychler's acid with different amines—unsubstituted as well as substituted—have been prepared by different workers with a view to determine the effect of chemical constitution on the optical rotary dispersion of these salts. The condensation products with naphthylamines were prepared by B. K. Singh and O. N. Perti[1] and with aniline and o-, m-, and p-toluidines by B. K. Singh and B. N. Singh[2] who determined their optical rotation in different solvents, and in each case found that the salts exhibit mutarotation in organic solvents but not in water. They attributed the mutarotation to the structural change in the salt into the ketimine or anil form with the liberation of a molecule of water. This explanation had also been advanced earlier by Schreiber and Shriner[3] to account for the mutarotation of primary amine salts of Reychler's acid in non-aqueous solvents. The condensation products of o-, m- and p-phenylene-diamine with Reychler's acid were prepared by M. S. Manhas and A. V. Mahajani[4] who found that the crystalline product obtained with o-phenylene-diamine was initially white and its colour changed gradually to deep orange when it was repeatedly crystallised out of a mixture of ethyl alcohol and ethyl acetate. They supposed that probably the deep orange compound is of the ketimine form. Further, the aqueous solution of the substance was found to give characteristic colour in acidic and alkaline media, suggesting its use as an acid-base indicator. They also determined the equivalent weight of this product potentiometrically and conductometrically. The potentiometric curve showed that the substance behaves as a monobasic acid and, therefore, its equivalent weight is the same as the molecular weight. These values were found to be very nearly the same as the calculated value for the molecular weight, assuming that the condensation proceeds without the elimination of a molecule of water.

The foregoing brief review of the work done on the condensation products of Reychler's acid with different aromatic amines clearly shows that no attempt has so far been made to determine the relative strengths, as monobasic acids, of the different condensation products and thereby to co-relate them with their chemical constitution. The present study was therefore undertaken to carry out conductometric and potentiometric titrations of the condensation products of aniline, toluidines, chloroanilines and phenylenediamines with Reychler's acid with a view to determine the molecular weights and the dissociation constants of the condensation products behaving as weak monobasic acids.

EXPERIMENTAL

Preparation of condensation products—Reychler's acid was prepared from recrystallised camphor according to the method of Reychler.[5]

The condensation products of aniline and of o-,m-, and p-toluidines with Reychler's acid were prepared according to the method of B. K. Singh (loc. cit.) while those of o-, m- and p-phenylene diamine were prepared according to the method of M. S. Manhas and A. V. Mahajani (loc. cit.) and of o-, m- and p-chloranilines according to the method used by B.K. Singh and O. N. Perti (loc. cit.)

Conductometric titrations—For carrying out the conductometric titrations conductivity meter of the type L.B.R./B reading to an accuracy of 1×10^{-9} mhos and a dipping cell with a cell constant of 0·415, were employed. The aqueous solution of a known weight of the condensation product was taken in a beaker immersed in a thermostat maintained at a constant temperature with an accuracy of $\pm 0{\cdot}1^\circ$ C. This was titrated against a standard aqueous solution of sodium hydroxide taken in a microburette. The conductivity observed was corrected for the changes in volume according to the equation:

Corrected conductivity=observed conductivity $\frac{V-V}{V}$ where V is the volume of the solution of the condensation product and v, the volume of alkali added.

Potentiometric titrations—These were conducted on Mullard potentiometer using the antimony electrode against the saturated calomel electrode. The values of pH of the solution at various stages of neutralisation were calculated from the observed e.m.f. values at 18°C from the following expression:

$$\mathrm{pH} = \frac{(\text{E observed} - \text{E}^\circ\ \text{sb}) - \text{E saturated Calomel}}{0{\cdot}0577}$$

the value of E° sb was experimentally determined by using standard buffer solution of sodium acetate and acetic acid and found to be 0·2069 volts.

RESULTS OF MEASUREMENTS

Conductometric titrations—The results obtained are shown graphically in figs. 1, 2 and 3. From these curves the equivalent points were read out and thereby the strength of the acid and the equivalent weight of the salt behaving as monobasic acid were calculated. They are given in table 1.

TABLE 1

Volume of solution of the condensation product taken=50 ml.

Condensation product with amount taken	Vol. of alkali required for titration	Strength of Na OH	Calculated equivalent weight (Molecular weight)	Theoretical Molecular weight
Aniline-Camphor Sulphonic Acid (0·06374 gm.)	10 cc.	N/50	318·7	325·0
o-Toluidine-Camphor Sulphonic acid (0·10208 gm.)	14·8 cc.	N/50	344·86	339·0
m-Toluidine ,, ,, (0·08274 gm.)	12·6 cc.	N/50	328·33	339·0
p- ,, ,, ,, (0·03656 gm.)	5·6 cc.	N/50	326·43	339·0
o-Chloro-aniline Camphor Sulphonic Acid (0·34000 gm.)	8·8 cc.	N/9·7	372·5	359·5
m- ,, ,, ,, (0·34000 gm.)	9·2 cc.	N/9·7	358·48	359·5
p- ,, ,, ,, (0·34000 gm.)	9·3 cc.	N/9·7	354·62	359·5
o-Phenylene-diamine Camphor Sulphonic acid (0·35408 gm.)	10·4 cc.	N/9·7	330·24	340·0
m- ,, ,, ,, ,, ,, (0·16320 gm.)	4·6 cc.	N/9·7	344·14	340·0
p- ,, ,, ,, ,, (0·31540 gm.)	4·8 cc.	N/5·1	335·10	340·0

Potentiometric titration of aniline-camphor sulphonic acid—0·3187 g. of the salt was dissolved in 250 cc. of conductivity water and 100 c.c. was taken for titration against a N/50 solution of NaOH. The results are tabulated below :—

TABLE 2

Sl. No.	Volume of Alkali added	E. M. F. in Volts	pH	$\frac{\Delta E}{\Delta V}$
1	5·0 cc.	0·242	4·939	...
2	10·0 cc.	0·268	5·372	...
3	13·0 cc.	0·282	5·615	$0·47\times10^{-2}$
4	15·0 cc.	0·294	5·823	$0·60\times10^{-2}$
5	17·0 cc.	0·310	6·000	$0·80\times10^{-2}$
6	18·0 cc.	0·324	6·343	$1·40\times10^{-2}$
7	18·5 cc.	0·336	6·551	$2·40\times10^{-2}$
8	19·0 cc.	0·350	6·793	$2·80\times10^{-2}$
9	19·5 cc.	0·378	7·279	$5·60\times10^{-2}$
10	19·7 cc.	0·420	8·009	$21·00\times10^{-2}$

(*Continued*)

TABLE 2 (*Contd.*)

Sl. No.	Volume of Alkali added	E.M.F. in Volts	pH	$\frac{\Delta E}{\Delta V}$
11	20·0 cc.	0·480	9·047	$20{\cdot}00\times10^{-2}$
12	20·5 cc.	0·520	9·740	$8{\cdot}00\times10^{-2}$
13	21·0 cc.	0·540	10·090	$4{\cdot}00\times10^{-2}$
14	22·0 cc.	0·564	10·502	$2{\cdot}40\times10^{-2}$
15	23·0 cc.	0·576	10·710	$1{\cdot}20\times10^{-2}$

The values of pH and of $\Delta E/\Delta V$ have been plotted against volume of alkali added and the curves obtained are shown in graphs 4 and 4A from which the equivalent point is read out and thereby the strength and the equivalent weight of the salt is calculated. Similarly the potentiometric titration curves for o-, m- and p-toluidine-camphor sulphonic acids are given in graphs 5 and 5A for o-, m- and p-chloro-aniline-camphor sulphonic acids in graphs 6 and 6A and for o-, m- and p-phenylene diamine-camphor sulphonic acids in graphs 7 and 7A.

On substitution of the values of pH in the Henderson equation at various stages of neutralisation the dissociation constant K*a* is calculated. The values of K*a* thus obtained are plotted against the square root of the base concentration and extrapolated to zero base concentration to evaluate the value of the true dissociation constant. These values for different condensation products are tabulated in table 3.

TABLE 3

Condensation Product	Weight dissolved into 250 cc. in gm.	Equiv. point	Equiv. weight (Mol. Wt)	Corrected dissociation constant	Theoretical Molecular weight
Aniline-camphor sulphonic acid	0·3187	19·8 cc.	321·9	$2{\cdot}65\times10^{-5}$	325·0
o-Toluidine-camphor-sulphonic acid	0·5104	28·7 cc.	353·8	$1{\cdot}60\times10^{-6}$	339·0
m- ,, ,, ,,	0·5910	36·0 cc.	328·33	$5{\cdot}50\times10^{-6}$	339·0
p- ,, ,, ,,	0·1828	11·2 cc.	326·4	$8{\cdot}00\times10^{-7}$	339·0
o-Chloro-aniline Camphor-Sulphonic acid	1·7000	18·0 cc.	366·4	$1{\cdot}70\times10^{-4}$	359·5
m- ,, ,, ,,	1·7000	18·5 cc.	356·5	$3{\cdot}60\times10^{-5}$	359·5
p- ,, ,, ,,	1·7000	18·7 cc.	353·8	$2{\cdot}72\times10^{-5}$	359·5
o-Phenylen-diamine-camphor-sulphonic acid	2·2130	25·6 cc.	335·4	$1{\cdot}52\times10^{-6}$	340·0
m- ,, ,, ,,	0·8160	9·3 cc.	340·4	$0{\cdot}50\times10^{-6}$	340·0
p- ,, ,, ,,	1·5770	9·6 cc.	335·1	$0{\cdot}48\times10^{-6}$	340·0

DISCUSSION

The present study shows that the equivalent weight and thereby the molecular weight of different camphor-β-sulphonates formed with amino compounds can be determined with fair accuracy by conductometric and potentiometric titrations against a strong base. These values compare satisfactorily with the theoretical values on the assumption that the condensation product is formed by condensation of one molecule of camphor-β-sulphonic acid and the corresponding amino compound in each case, without the elimination of water. This result is in conformity with the observation of Singh, Perti and Singh[6] that the primary amine salts of d- or l-camphor-β-sulphonic acids undergo mutarotation in non-aqueous solvents owing to a structural change in the salt into ketimine or anil, but not in aqueous solutions.

A critical examination of the values of the dissociation constants of the different condensation products behaving as monobasic acids shows that the value is affected both by the nature and the position of the substituent. Thus when $-CH_3$ group is substituted in the amine, the dissociation constant is decreased in accordance with the Ostwald's rule.[7] Further, the value also changes when we pass from the condensation product of o- to p-toluidine. On the other hand, when the electronegative group Cl is substituted for hydrogen in o-, m- and p-positions in the benzene ring, the dissociation constant of the product increases greatly in the order $K_o > K_m > K_p$, which is due to the electron-attracting character of the substituent. The introduction of another NH_2 group in the benzene ring of the amine (phenylene diamine camphor-β-sulphonates) brings about a decrease in the dissociation constant, this is also in conformity with the classification of groups given by Ostwald (loc. cit.), further, as expected, this decrease is the greatest in the case of ortho derivative.

ACKNOWLEDGEMENT

We are grateful to Dr. O. N. Perti, Head of the Chemistry Department, for his valuable suggestions throughout the course of this investigation.

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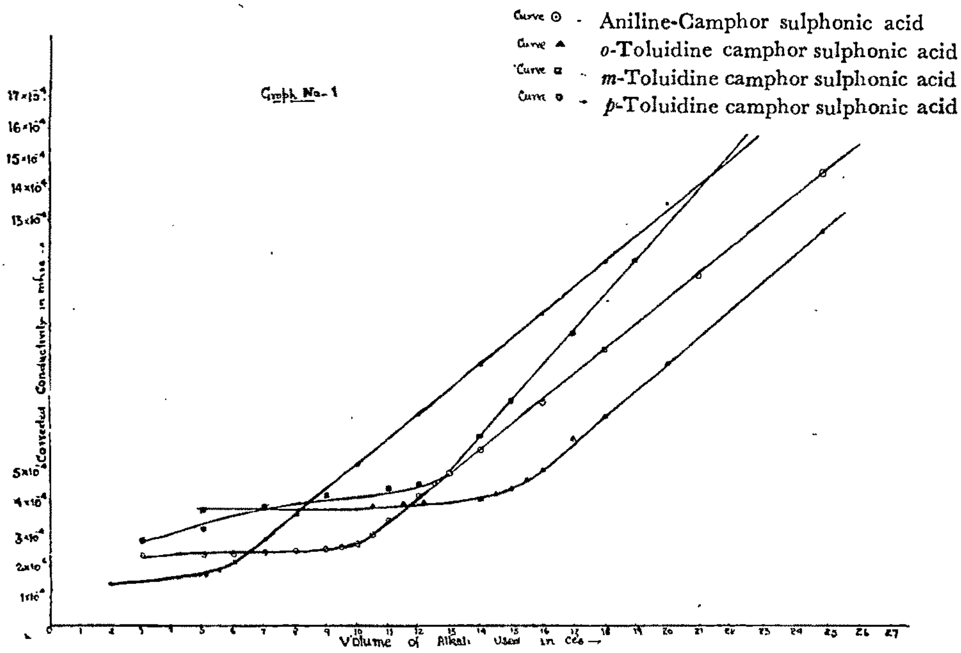
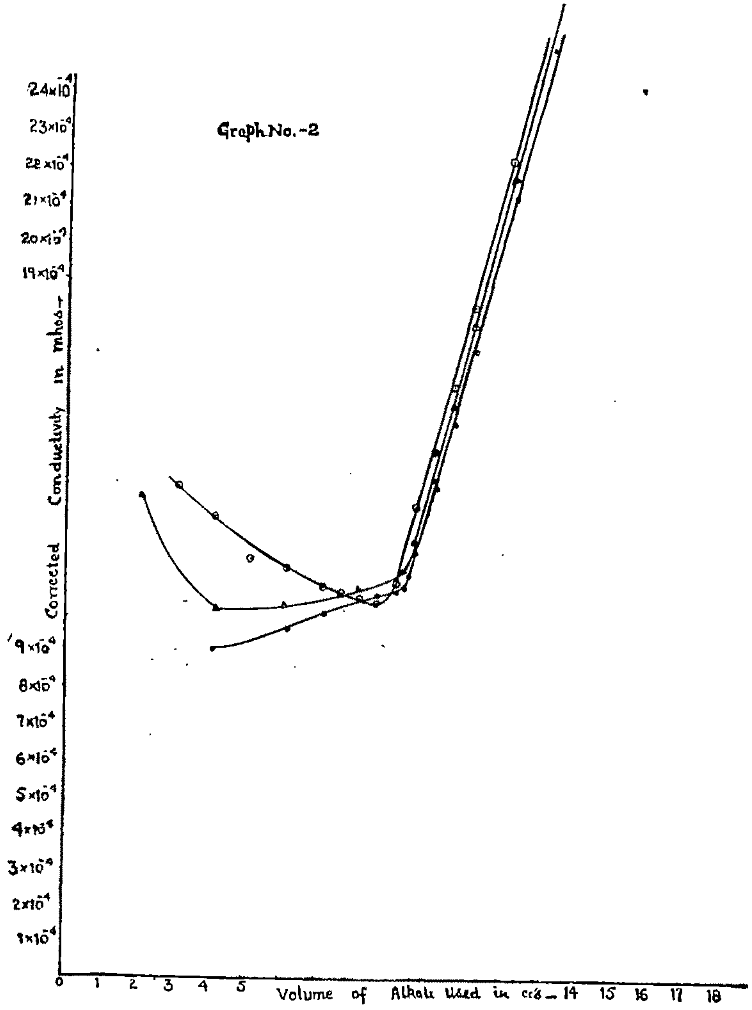
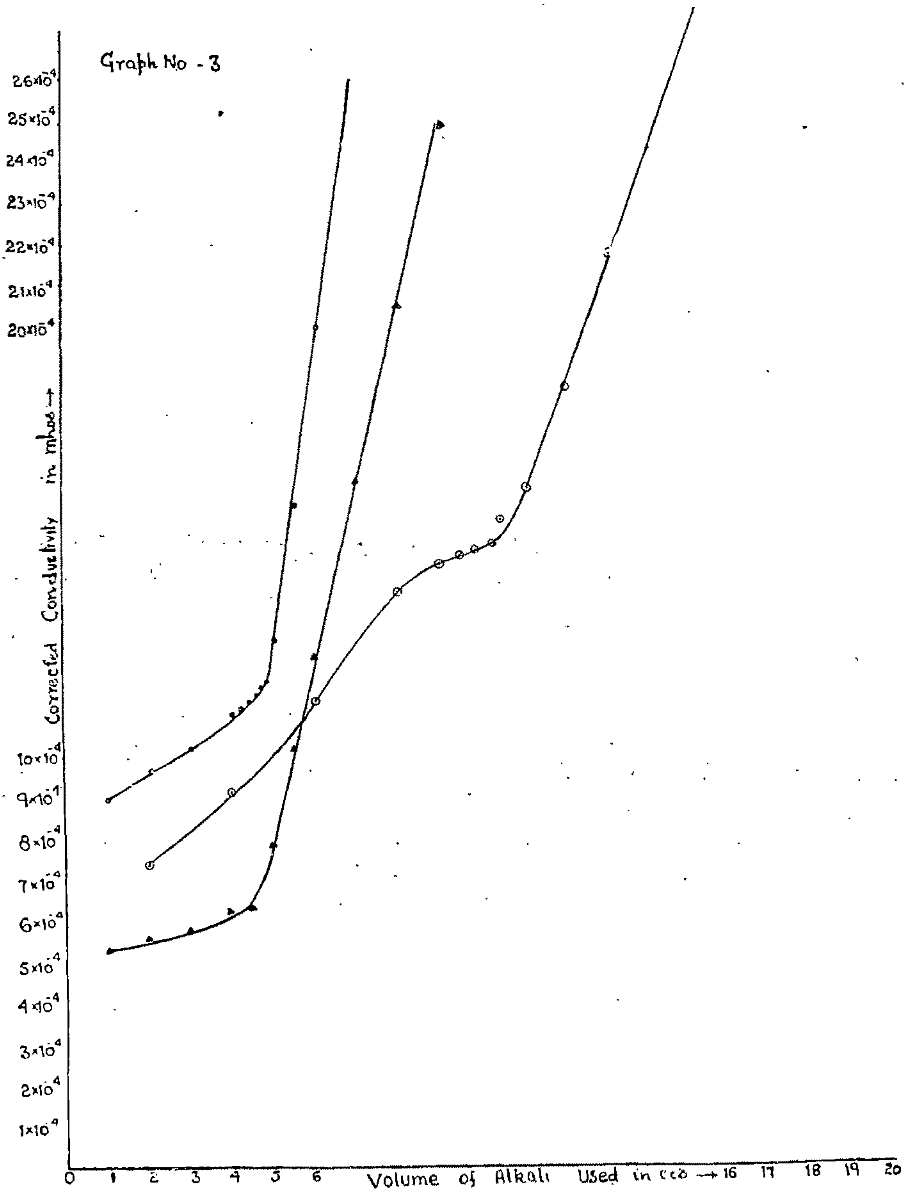
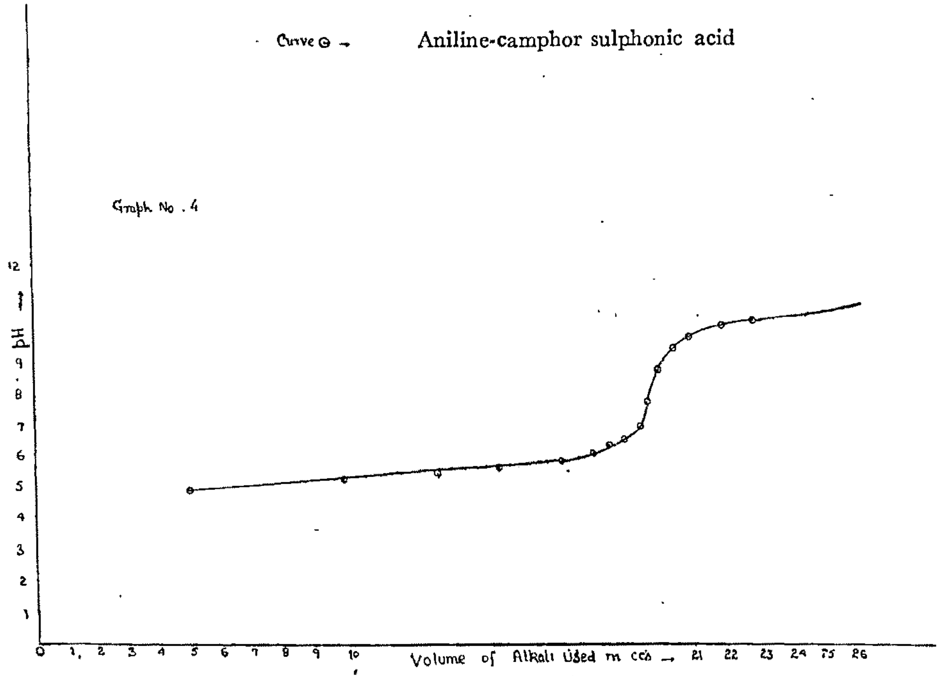

Curve ⊙ - Aniline-Camphor sulphonic acid
Curve ▲ o-Toluidine camphor sulphonic acid
Curve ▫ - m-Toluidine camphor sulphonic acid
Curve ○ - p-Toluidine camphor sulphonic acid
Graph No-1
17×10⁻⁴
16×10⁻⁴
15×10⁻⁴
14×10⁻⁴
13×10⁻⁴
5×10⁻⁴
4×10⁻⁴
3×10⁻⁴
2×10⁻⁴
1×10⁻⁴
Corrected Conductivity in mhos →
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
Volume of Alkali Used in Ccs →

Curve ⊙ → *o*-Chloro aniline-camphor sulphonic acid
Curve ▲ → *m*-Chloro aniline-camphor sulphonic acid
Curve ● → *p*-Chloro aniline-camphor sulphonic acid

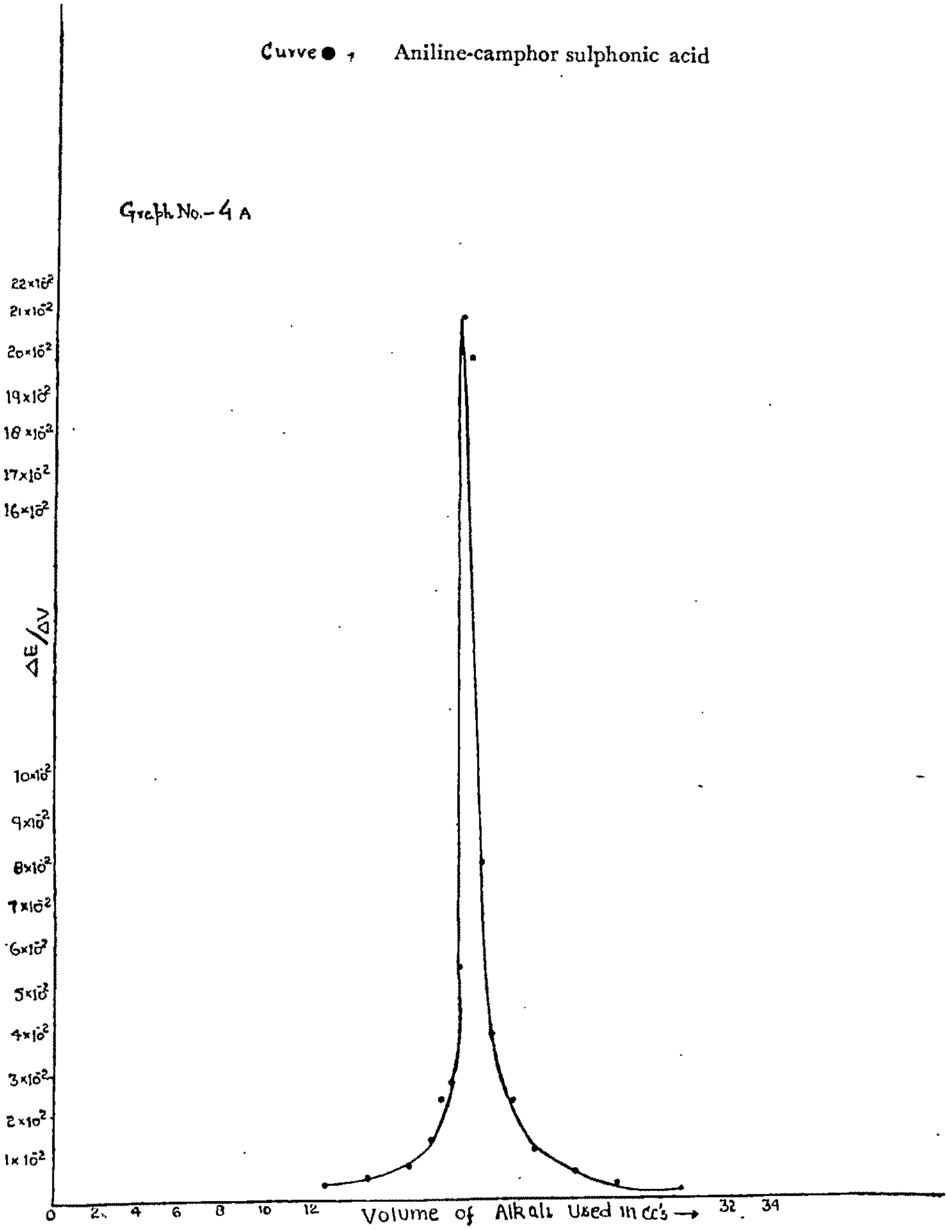


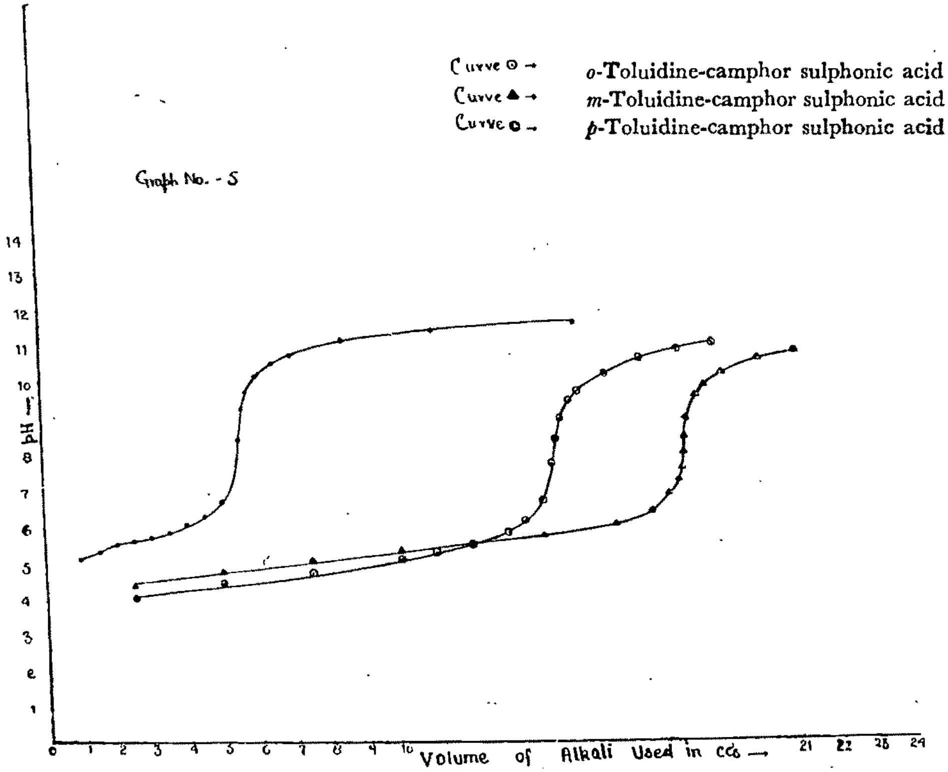
Curve ⊙ → *o*-Phenylene-diamine-camphor sulphonic acid
Curve ▲ → *m*-Phenylene-diamine-camphor sulphonic acid
Curve ● → *p*-Phenylene-diamine-camphor sulphonic acid

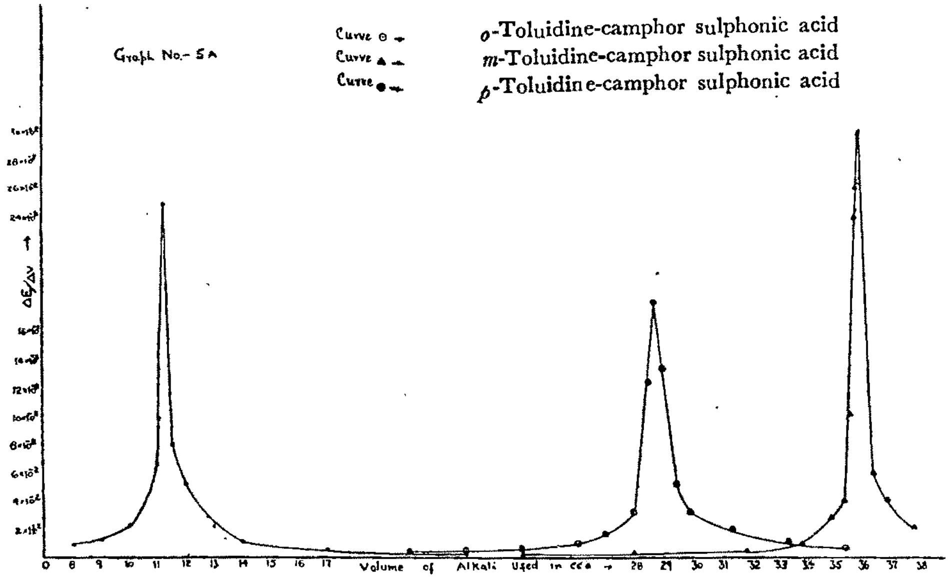


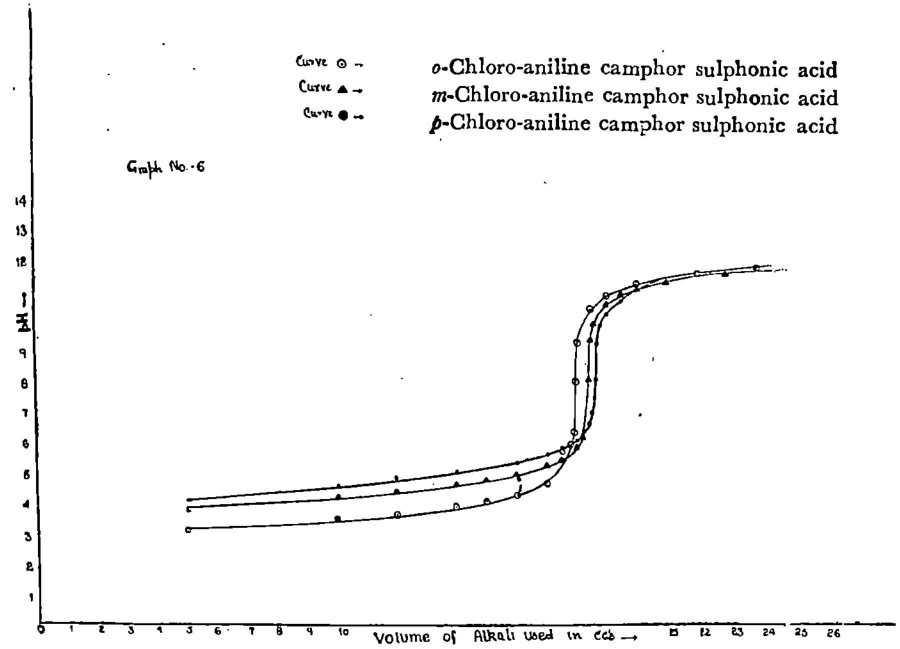


Curve ⊖ → Aniline-camphor sulphonic acid


Curve ● Aniline-camphor sulphonic acid
Graph No.-4 A
22×10⁻²
21×10⁻²
20×10⁻²
19×10⁻²
18×10⁻²
17×10⁻²
16×10⁻²
ΔE/ΔV
10×10⁻²
9×10⁻²
8×10⁻²
7×10⁻²
6×10⁻²
5×10⁻²
4×10⁻²
3×10⁻²
2×10⁻²
1×10⁻²
0
2
4
6
8
10
12
Volume of Alkali Used in cc's →
32
34

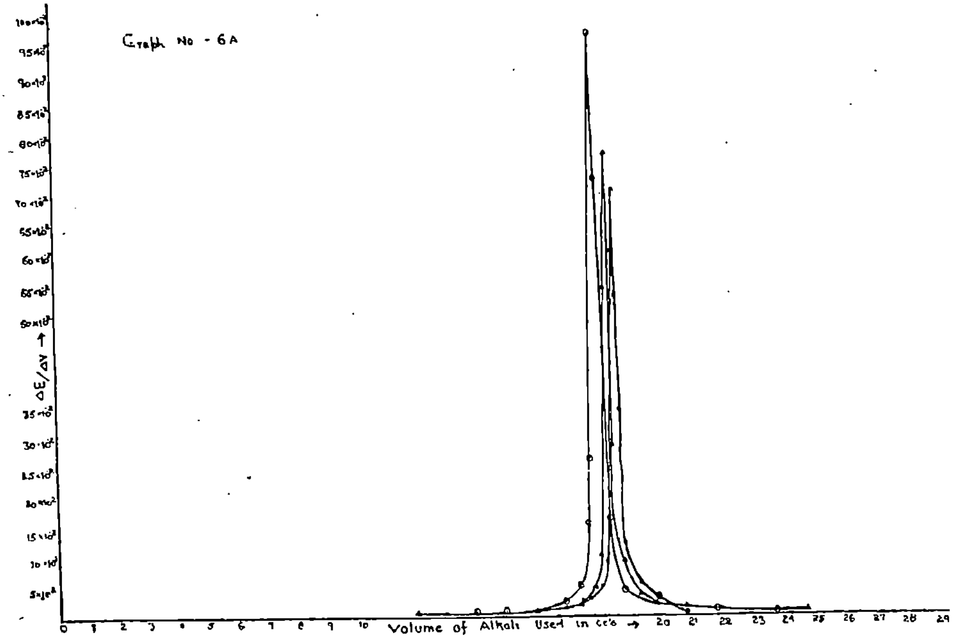

Curve ⊙ → o-Toluidine-camphor sulphonic acid
Curve ▲ → m-Toluidine-camphor sulphonic acid
Curve ● → p-Toluidine-camphor sulphonic acid
Graph No. - 5
pH →
14
13
12
11
10
8
7
6
5
4
3
2
1
0 1 2 3 4 5 6 7 8 9 10
Volume of Alkali Used in ccs →
21 22 23 24

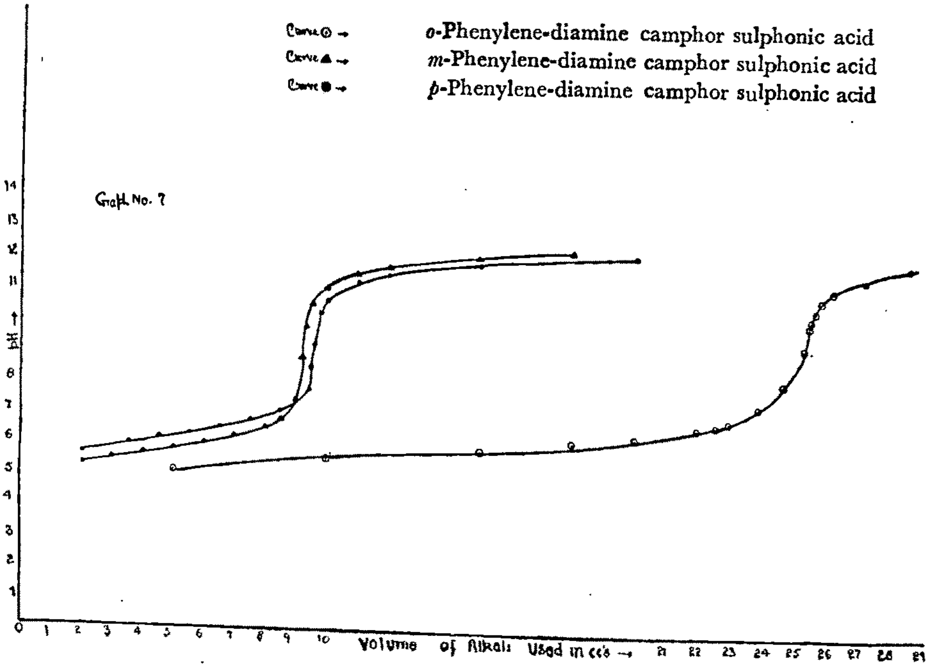

Graph No.- 5A
Curve ⊙ → o-Toluidine-camphor sulphonic acid
Curve ▲ → m-Toluidine-camphor sulphonic acid
Curve ● → p-Toluidine-camphor sulphonic acid
ΔE/ΔV →
0 8 9 10 11 12 13 14 15 16 17
Volume of Alkali Used in ccs →
28 29 30 31 32 33 34 35 36 37 38

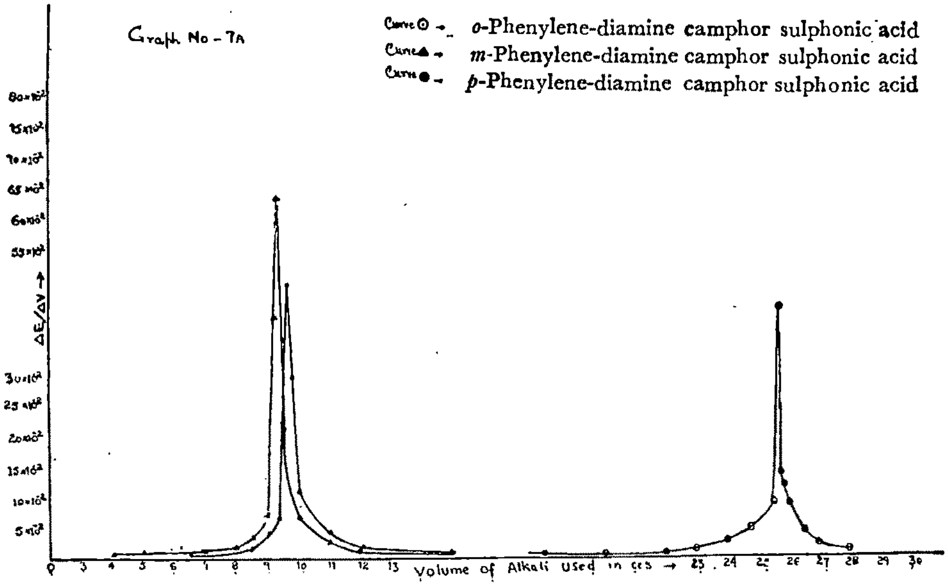


o-Chloro-aniline camphor sulphonic acid
m-Chloro-aniline camphor sulphonic acid
p-Chloro-aniline camphor sulphonic acid

Curve ⊙ → *o*-Chloro-aniline camphor sulphonic acid
Curve ▲ → *m*-Chloro-aniline camphor sulphonic acid
Curve ● → *p*-Chloro-aniline camphor sulphonic acid




Curve ⊙ → *o*-Phenylene-diamine camphor sulphonic acid
Curve ▲ → *m*-Phenylene-diamine camphor sulphonic acid
Curve ● → *p*-Phenylene-diamine camphor sulphonic acid
Graph No. 7
pH →
14
13
12
11
8
7
6
5
4
3
2
1
0
Volume of Alkali Used in cc's →
21
22
23
24
25
26
27
28
29


Graph No - 7A
Curve ⊙ → *o*-Phenylene-diamine camphor sulphonic acid
Curve ▲ → *m*-Phenylene-diamine camphor sulphonic acid
Curve ● → *p*-Phenylene-diamine camphor sulphonic acid
ΔE/ΔV →
80×10²
75×10²
70×10²
65×10²
60×10²
55×10²
30×10²
25×10²
20×10²
15×10²
10×10²
5×10²
0
Volume of Alkali Used in cc's →
23
24
25
26
27
28
29
30

STUDIES ON THE FLOW OF BINARY MIXTURES OF AROMATIC HYDROCARBONS THROUGH ADSORBENT COLUMNS

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Gupta and Bhattacharya [1—4] have measured the velocity of flow $\left(\frac{V}{t}\right)$ of several liquids through different adsorbent columns and have shown that the values of $\frac{vh\eta}{td}$, where h is the height of the column, d the density and η the viscosity of liquids, are constant for water and organic liquids belonging to the same homologous series. We have measured the rates of flow of binary mixtures of aromatic hydrocarbons at the optimum height of the adsorbent columns and the results obtained are communicated through this paper.

EXPERIMENTAL

The experimental technique employed was the same as described by Gupta and Bhattacharya (loc. cit.). The Analar pure samples of adsorbents, alumina, calcium carbonate and magnesia used, were sun dried and seived through a 100 mesh sieve. The particles of the adsorbent were stirred in the organic liquid and packed uniformly as far as possible by pouring the suspensions in a chromatographic tube fitted at the bottom with a perforated porcelain disc and a thin pad of the asbestos wool. The desired suction tension was applied through the stem of the chromatographic tube. The asbestos pad arrests the adsorbent particles from draining out, and a succession of the uniform layers goes on settling in the tube. As the height of the adsorbent column increases, the suction tension is also increased. Efforts were made to maintain uniform compactness of the adsorbent till the optimum range of height (4-5 cms.) was reached. The liquid whose rate of flow was studied was filled in the tube to the brim so that the hydrostatic pressure on the column may remain constant. This was achieved by fitting a microburette vertically which carried the same liquid.

The results obtained are given in the following tables and shown graphically in Figs. 1, 2 and 3.

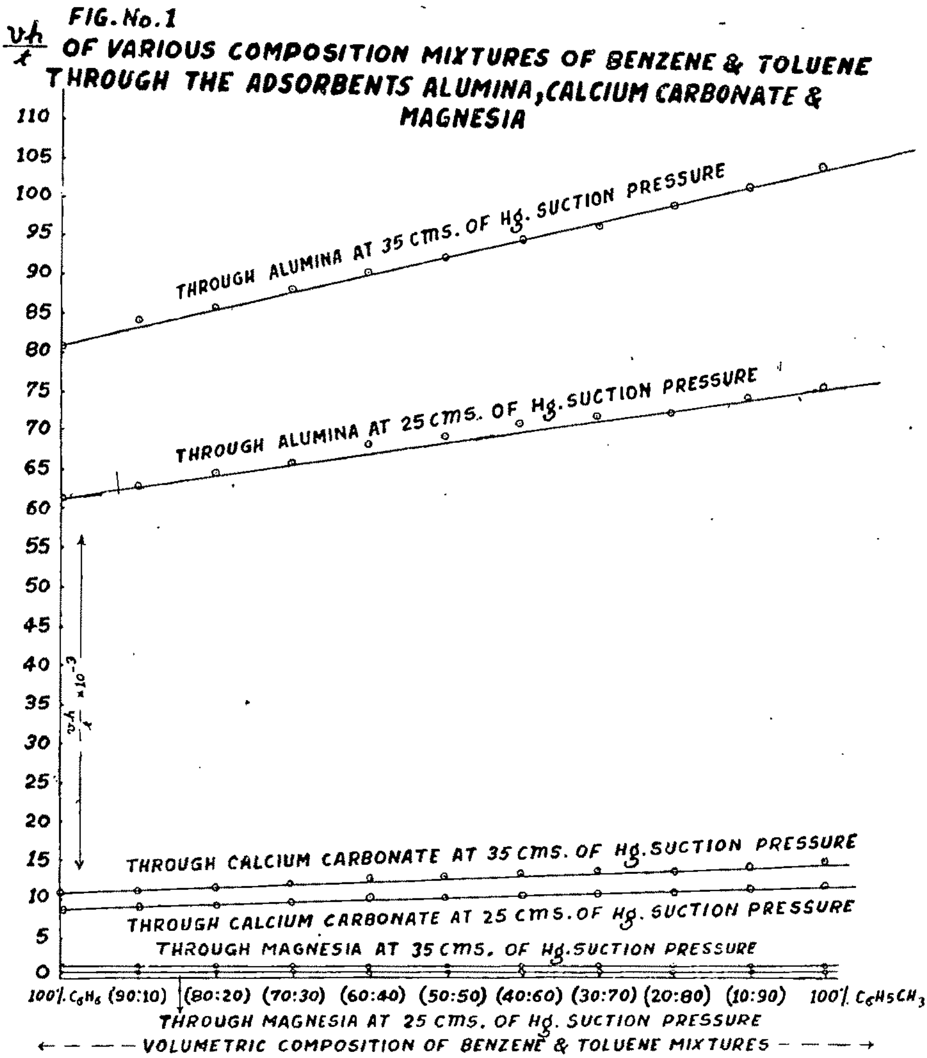

FIG. No. 1

$\frac{vh}{t}$ OF VARIOUS COMPOSITION MIXTURES OF BENZENE & TOLUENE THROUGH THE ADSORBENTS ALUMINA, CALCIUM CARBONATE & MAGNESIA

FIG. No. 2

OF VARIOUS COMPOSITION MIXTURES OF BENZENE & XYLENE THROUGH THE SAME SET OF ABSORBENTS AS IN FIG. No. 1

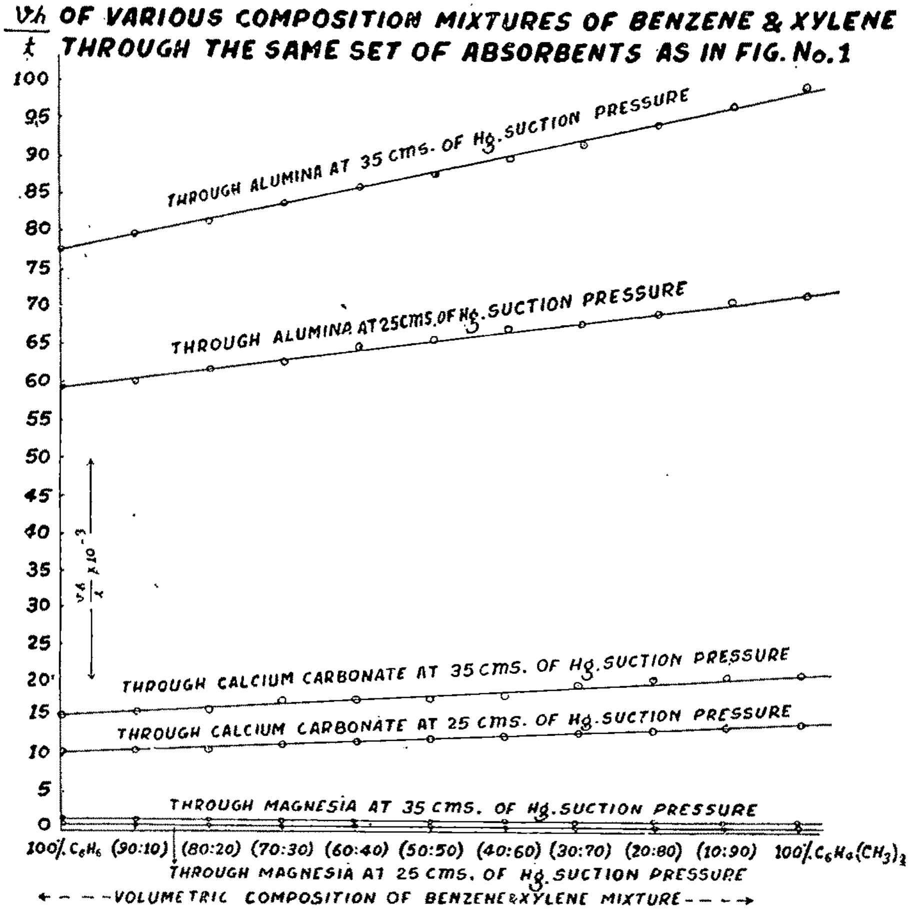

FIG. No. 3

$\frac{vh}{t}$ OF VARIOUS COMPOSITION MIXTURES OF TOLUENE & XYLENE THROUGH THE SAME SET OF ADSORBENTS AS IN FIG. No. 1

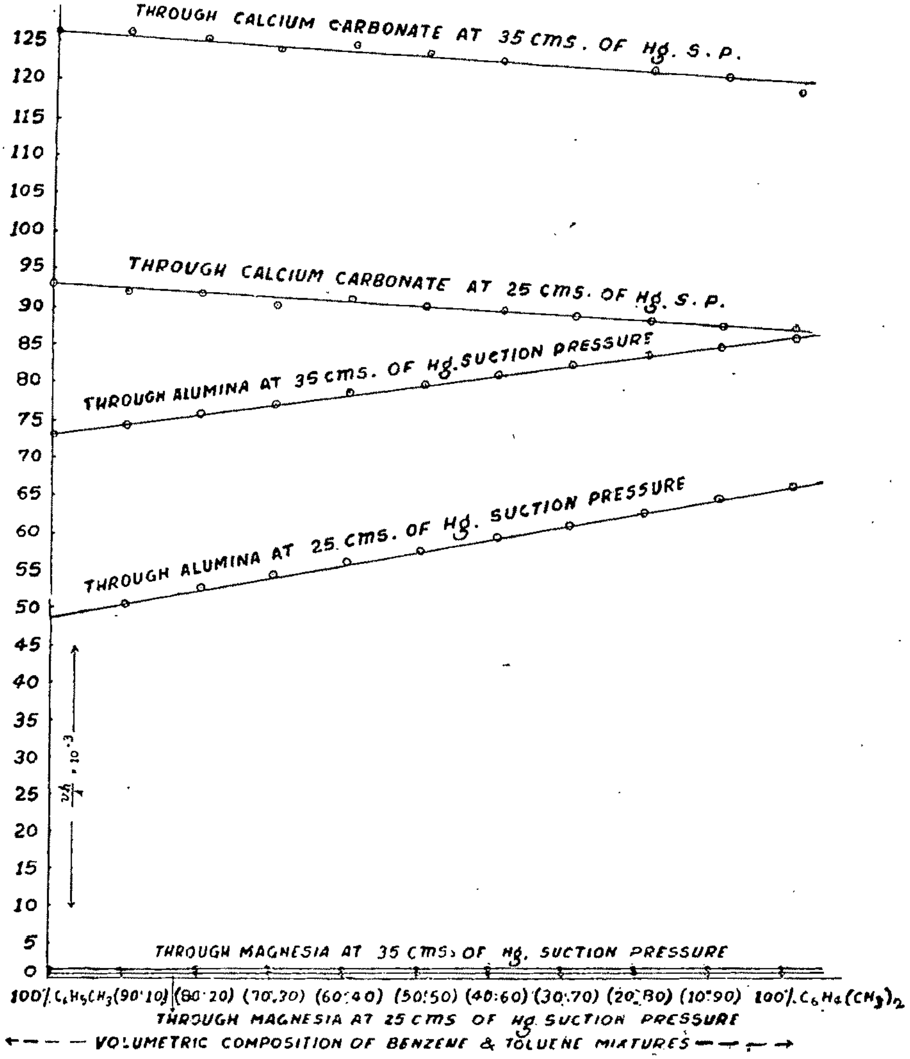

TABLE 1

ADSORBENT—ALUMINA

Height of the column (h)=4·300 cms. Temperature=20° C

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Benzene	Toluene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	52·4	82·04×10^{-3}	69·7	61·70×10^{-3}
45 ,,	5 ,,	,,	51·0	84·32 ,,	68·2	63·10 ,,
40 ,,	10 ,,	,,	49·8	86·34 ,,	66·5	64·46 ,,
35 ,,	15 ,,	,,	48·4	88.86 ,,	65.2	66.00 ,,
30 ,,	20 ,,	,,	46·1	90·99 ,,	63·2	68·19 ,,
25 ,,	25 ,,	,,	46·1	93·27 ,,	62·3	69·00 ,,
20 ,,	30 ,,	,,	45·0	95·57 ,,	60·8	70·70 ,,
15 ,,	35 ,,	,,	44·1	97·57 ,,	60·1	71·57 ,,
10 ,,	40 ,,	,,	42·8	100·50 ,,	59·7	72·00 ,,
5 ,,	45 ,,	,,	41·7	103·10 ,,	57·5	74·70 ,,
0 ,,	50 ,,	,,	40·5	106·10 ,,	57·3	75·00 ,,

TABLE 2

Height of the column=4·238 cms.

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Benzene	Xylene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	54·3	78·02×10^{-3}	71·9	58·94×10^{-3}
45 ,,	5 ,,	,,	53·1	79·80 ,,	70·4	60·19 ,,
40 ,,	10 ,,	,,	51·9	81·63 ,,	68·7	61·67 ,,
35 ,,	15 ,,	,,	50·5	83·90 ,,	67·4	62·86 ,,
30 ,,	20 ,,	,,	49·3	85·93 ,,	65·5	64·70 ,,
25 ,,	25 ,,	,,	49·2	87·91 ,,	64·5	65·69 ,,
20 ,,	30 ,,	,,	47·1	89·97 ,,	63·0	67·26 ,,
15 ,,	35 ,,	,,	46·2	91·71 ,,	62·3	68·01 ,,
10 ,,	40 ,,	,,	44·9	94·39 ,,	60·9	69·60 ,,
5 ,,	45 ,,	,,	43·8	96·74 ,,	59·7	70·98 ,,
0 ,,	50 ,,	,,	42·6	99·43 ,,	58·8	72·05 ,,

TABLE 3

Height of the column = 4·226 cms.

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Toluene	Xylene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	57·6	$73{\cdot}35\times10^{-3}$	86·2	$49{\cdot}03\times10^{-3}$
45 ,,	5 ,,	,,	56·7	74·34 ,,	82·7	51·09 ,,
40 ,,	10 ,,	,,	55·6	76·02 ,,	80·1	52·73 ,,
35 ,,	15 ,,	,,	54·8	77.13 ,,	77·5	54·51 ,,
30 ,,	20 ,,	,,	53·8	78·56 ,,	75·4	56·03 ,,
25 ,,	25 ,,	,,	53·0	79·75 ,,	73·5	57·50 ,,
20 ,,	30 ,,	,,	52·1	81·10 ,,	71·2	59·31 ,,
15 ,,	35 ,,	,,	51·2	82·52 ,,	69·3	60·98 ,,
10 ,,	40 ,,	,,	50·5	83·68 ,,	67·4	62·70 ,,
5 ,,	45 ,,	,,	49·9	84·67 ,,	65·5	64·37 ,,
0 ,,	50 ,,	,,	49·1	85·88 ,,	64·0	66·07 ,,

TABLE 4

ADSORBENT—CALCIUM CARBONATE

Height of the column (h) = 4·275 cms. Temperature = 20° C

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Benzene	Toluene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	376·6	$11{\cdot}3\times10^{-3}$	462·4	$9{\cdot}24\times10^{-3}$
45 ,,	5 ,,	,,	375·0	11·4 ,,	460·7	9·281 ,,
40 ,,	10 ,,	,,	358·4	11·92 ,,	445·9	9·583 ,,
35 ,,	15 ,,	,,	344·3	12·42 ,,	425·2	10·070 ,,
30 ,,	20 ,,	,,	336·2	12·72 ,,	417·1	10·240 ,,
25 ,,	25 ,,	,,	328·5	13·01 ,,	414·2	10·310 ,,
20 ,,	30 ,,	,,	320·3	13·35 ,,	407·2	10·500 ,,
15 ,,	35 ,,	,,	316·4	13·51 ,,	398·7	10·720 ,,
10 ,,	40 ,,	,,	309·8	13·79 ,,	393·2	10·820 ,,
5 ,,	45 ,,	,,	301·2	14·23 ,,	377·7	11·320 ,,
0 ,,	50 ,,	,,	292·3	14·63 ,,	369·3	11·590 ,,

TABLE 5

Height of the column=4·228 cms.

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Benzene	Xylene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	275·5	$15{\cdot}34\times10^{-3}$	409·4	$10{\cdot}33\times10^{-3}$
45 ,,	5 ,,	,,	265·2	15·94 ,,	393·9	10·74 ,,
40 ,,	10 ,,	,,	273·7	15·45 ,,	385·2	10·97 ,,
35 ,,	15 ,,	,,	239·0	17·69 ,,	361·0	11·71 ,,
30 ,,	20 ,,	,,	234·1	18·07 ,,	355·2	11·89 ,,
25 ,,	25 ,,	,,	235·3	17·93 ,,	335·4	12·60 ,,
20 ,,	30 ,,	,,	224·5	18·33 ,,	326·3	13·01 ,,
15 ,,	35 ,,	,,	212·4	19·90 ,,	319·2	13·24 ,,
10 ,,	40 ,,	,,	203·3	20·80 ,,	311·3	13·58 ,,
5 ,,	45 ,,	,,	201·7	20·96 ,,	298·8	14·15 ,,
0 ,,	50 ,,	,,	201·4	21·04 ,,	292·0	14·47 ,,

TABLE 6

Height of the column=4·228 cms.

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Toluene	Xylene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	33·2	$127{\cdot}4\times10^{-3}$	45·3	$93{\cdot}12\times10^{-3}$
45 ,,	5 ,,	,,	33·4	126·6 ,,	45·9	92·13 ,,
40 ,,	10 ,,	,,	33·7	125·4 ,,	46·0	91·92 ,,
35 ,,	15 ,,	,,	34·1	124·0 ,,	46·8	90·38 ,,
30 ,,	20 ,,	,,	34·0	124·3 ,,	46·5	90·92 ,,
25 ,,	25 ,,	,,	34·3	123·2 ,,	46·9	90·14 ,,
20 ,,	30 ,,	,,	34·5	122·5 ,,	47·3	89·37 ,,
15 ,,	35 ,,	,,	34·7	119·3 ,,	47·6	88·92 ,,
10 ,,	40 ,,	,,	34·9	121·2 ,,	48·0	88·06 ,,
5 ,,	45 ,,	,,	35·2	120·1 ,,	49·5	87·20 ,,
0 ,,	50 ,,	,,	35·9	117·5 ,,	49·1	85·92 ,,

TABLE 7

ADSORBENT—MAGNESIA

Height of the column (h)$=4{\cdot}349$ *cms. Temperature*$=20°$ *C*

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Benzene	Toluene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	612·5	$0{\cdot}7112\times10^{-3}$	812·2	$0{\cdot}5359\times10^{-3}$
45 ,,	5 ,,	,,	604·9	0·7216 ,,	802·3	0·5420 ,,
40 ,,	10 ,,	,,	593·8	0·7343 ,,	805·5	0·5408 ,,
35 ,,	15 ,,	,,	588·0	0·7399 ,,	810·4	0·5367 ,,
30 ,,	20 ,,	,,	587·3	0·7406 ,,	815·3	0·5337 ,,
25 ,,	25 ,,	,,	587·4	0·7406 ,,	816·2	0·5327 ,,
20 ,,	30 ,,	,,	580·2	0·7494 ,,	799·1	0·5445 ,,
15 ,,	35 ,,	,,	589·8	0·7372 ,,	789·2	0·5511 ,,
10 ,,	40 ,,	,,	570·2	0·7625 ,,	774·4	0·5601 ,,
5 ,,	45 ,,	,,	561·3	0·7733 ,,	763·2	0·5702 ,,
0 ,,	50 ,,	,,	556·1	0·7823 ,,	754·9	0·5758 ,,

TABLE 8

Height of the column$=4{\cdot}218$ *cms.*

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Benzene	Xylene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	769·2	$0{\cdot}561\times10^{-3}$	999·6	$0{\cdot}432\times10^{-3}$
45 ,,	5 ,,	,,	752·3	0·574 ,,	997·7	0·433 ,,
40 ,,	10 ,,	,,	733·4	0·588 ,,	1001·9	0·431 ,,
35 ,,	15 ,,	,,	725·2	0·595 ,,	993·5	0·434 ,,
30 ,,	20 ,,	,,	716·0	0·603 ,,	982·2	0·439 ,,
25 ,,	25 ,,	,,	710·3	0·607 ,,	974·7	0·443 ,,
20 ,,	30 ,,	,,	691·3	0·623 ,,	994·4	0·434 ,,
15 ,,	35 ,,	,,	660·3	0·653 ,,	976·2	0·443 ,,
10 ,,	40 ,,	,,	616·3	0·667 ,,	969·2	0·446 ,,
5 ,,	45 ,,	,,	633·2	0·682 ,,	960·6	0·449 ,,
0 ,,	50 ,,	,,	623·2	0·694 ,,	947·8	0·456 ,,

TABLE 9

Height of the column = 4·226 cms.

Composition		Volume flowed in c.c.	At 35 cms. mercury pressure		At 25 cms. mercury pressure	
Toluene	Xylene	v	Time (t) in Secs.	$\frac{vh}{t}$	Time (t) in Secs.	$\frac{vh}{t}$
50 c.c.	0 c.c.	1	784·3	$0·540 \times 10^{-3}$	998·4	$0·431 \times 10^{-3}$
45 ,,	5 ,,	,,	798·3	0·539 ,,	1006·3	0·427 ,,
40 ,,	10 ,,	,,	809·2	0·531 ,,	1016·3	0·423 ,,
35 ,,	15 ,,	,,	811·3	0·530 ,,	1024·4	0·420 ,,
30 ,,	20 ,,	,,	819·7	0·525 ,,	1013·4	0·424 ,,
25 ,,	25 ,,	,,	823·8	0·522 ,,	1031·0	3·417 ,,
20 ,,	30 ,,	,,	827·4	0·519 ,,	1035·3	0·415 ,,
15 ,,	35 ,,	,,	825·3	0·520 ,,	1045·2	0·411 ,,
10 ,,	40 ,,	,,	831·2	0·517 ,,	1057·7	0·463 ,,
5 ,,	45 ,,	,,	835·2	0·515 ,,	1064·5	0·403 ,,
0 ,,	50 ,,	,,	837·4	0·513 ,,	1065·1	0·403 ,,

DISCUSSION

It will be seen from the graphs in the three figures that there is a linear relationship between $\frac{Vh}{t}$ and volumetric composition of binary mixtures used in this investigation.

Figure 1 shows that as the benzene content in the mixture decreases, the value of $\frac{Vh}{t}$ increases in the case of alumina and calcium carbonate adsorbents. The rate of increase of $\frac{Vh}{t}$ with the alumina adsorbent is greater than that with calcium carbonate. Further, there is a wider gap in the two straight lines of alumina than those of calcium carbonate at the two pressures. The same behaviour is observed in figure 2 in these cases. This shows that alumina molecules have little or negligible surface effect on the rate of flow of molecules of aromatic hydrocarbons while molecules of calcium carbonate suffer some surface effect. This may be due to the non-polar character of alumina and the polar character of calcium carbonate molecules which cause interaction (cohesion or adhesion) with benzene molecules.

The two straight lines with magnesia adsorbent are just at the bottom in all the three figures, and are very close and parallel to each other. This shows that the interaction between adsorbent molecules of hydrocarbons is much greater with magnesia than with calcium carbonate. This observation further shows that while calcium carbonate interacts only with benzene, magnesia interacts with all the molecules of the homologous series, and the interaction is so large that the rate of flow of mixtures of various compositions does not change with the nature of the compositions and the magnitude of the suction pressure.

The linear relationship between $\frac{Vh}{t}$ and the composition of mixtures with alumina adsorbent is at the same level in all the three figures, but in the case of calcium carbonate, this is so only in the third figure and not in the first two on account of the interaction between the benzene and calcium carbonate molecules.

SUMMARY

The rates of flow of different compositions of benzene, toluene and xylene have been determined through alumina, calcium carbonate and magnesia. A linear relationship exists between $\frac{Vh}{t}$ and volumetric compositions of binary mixtures in all the three cases. Alumina molecules maintain normal behaviour when they are in contact with aromatic hydrocarbon molecules. Calcium carbonate molecules maintain the normal behaviour only when there is no benzene in the mixture, on account of interaction between them. Magnesia molecules suffer interaction with all the aromatic hydrocarbon molecules.

ACKNOWLEDGEMENTS

The authors express their grateful thanks to Dr. A. K. Bhattacharya, Professor of Chemistry, University of Jammu and Kashmir, Srinagar and Dr. W. U. Malik, Professor of Chemistry, University of Roorkee, Roorkee for their keen interest in this work.

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INDUCTION OF MALE STERILITY IN MUSKMELON BY THE USE OF F.W. 450.

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Since the value of hybrid vigour has been recognized in the improvement of crops, breeders have taken a keen interest in the production of hybrid seeds on commercial scale (see Duvick, 1959).

In muskmelon the male and female blossoms are produced separately on the same plant, it may be possible that the male flowers may be removed from the seed row's plants by hand. These plants may either be left for natural pollination from the pollen carried by the insects from the non-seed row plants or may be hand pollinated. But this method of removal would disturb the vine. According to Burrell (1939) disturbances of this sort have been found to upset the normal physiology of the plants resulting in very low percentage of fruit and seed-set. Seaton and Kramer (1939) have stated that by hand pollination fruit-set was only 5 to 10%. Burrell (1939) has also observed that under very favourable conditions the percentage of fruit-setby hand pollination may be as high as 20%. These findings demonstrate that the technique of bagging the female flowers and then hand pollinating them cannot be used for the large scale hybrid seed production.

This difficulty could be overcome by adopting the recently discovered method of inducing male sterility by the application of certain chemicals called as gametocides, which possess the property of killing the pollen or the pollen mother cells without injuring the female parts.

In recent years the induction of male sterility has become a forceful tool in the hands of plant breeders to produce hybrid seeds in crops; for example, tobacco, maize and cocklebur (Naylor, 1950a, 1950b), cucurbits (Wittiver and Hillyer, 1954), cotton (Eaton, 1957; Meyer, Roux and Thomas, 1958), tomatoes (Moore, 1959), wheat, onion and tomato (Chopra, Jain and Swaminathan, 1960), soyabeans (Starnes and Hadley, 1960) and sorghum (Miller and Hittle, 1960; and Miller, 1961). Keeping these points in view an attempt has been made to induce male sterility in muskmelon for use in hybrid seed production by the use of F. W. 450.

MATERIAL AND METHOD

In the experiment sodium alpha, beta-dichloroisobutyrate (F.W.450) was used as gametocide and the experiment was performed at B. R. College, Research Station, Bichpuri, Agra (India).

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Healthy seeds of Mao variety of muskmelon were sown in 4 replication in February, 1963, each replication consisting of 3 rows of plants. The treatment was started in the first week of April when first visible sign of floral initiation was noticeable.

Concentrations of F. W. 450 used for treatment were 0·3%, 0·4%, 0·5% and 0·6% prepared in aqueous media. The solution was applied by multi-direction foliar spray. All treatments were given at sun-set time.

With each concentration, three types of treatments were given : (A)—plants were sprayed only once, (B)—plants were sprayed twice at an interval of 5 days, and (C)—plants were sprayed thrice also at an intervals of 5 days. Controls were maintained by spraying with distilled water in the manner exactly like those in which gametocide was sprayed.

The growth ratio among all plants was taken by observing the length of the main shoot, number of laterals, number of leaves and flowers. Histograms are prepared to demonstrate the effect of the chemical on the growth of the plants. Observations were also made on the development of male flower, opening of the corolla, shape and size of anthers, dehiscibility of anthers and the viability of pollen grains. Pollen viability was tested with acetocarmine staining technique.

OBSERVATIONS

When F. W. 450 was applied at 0·3% (A) concentration, the phytotoxicity was low. Only the growth was retarded (*see* Fig. 1) and shoot apex was not injured. Recovery of plants was rapid. Plant produced all fertile pollen.

In 0·4% (A) concentration treatment, moderate yellowing and burning of foliage occurred (Fig. 3). In this case also growing apex was not affected. Recovery of plant was rapid.

When two sprays at an internal of 5 days of 0·3% concentration were given, the intensity of damage was increased and growth was delayed (Fig. 2). On these plants the gametocide seems to be effective on the buds which were developing at the time of application because these buds later on showed undehisced anthers with viable germinated pollen. Development of non-dehiscent anthers with viable pollen shows that this treatment has resulted in the induction of functional male sterility. The buds which were developed later on, produced normal flowers showing clearly that the spray had no effect on them.

By two sprays of 0·4% concentration the intensity of injury was higher. Main shoot apex was severely burnt (Fig. 4). A lateral branch developed which produced three male flowers with crumpled and shrunken anther lobes (Fig 5-left). These anther lobes were narrow and smaller than the control (*see* Fig. 5). Almost all pollen grains were non-viable. These male sterile flowers had short, feeble pedicles. The corolla too was conspicuously smaller.

With higher concentrations and more number of sprays the plants were extremely damaged. Yellowing and foliage burning was extensive. Growing apex also showed burning symptoms and the growth was highly retarded. In these cases plants did not achieve the normal size. After about 15-20 days, however, lateral shoots were initiated but they too showed a slow growth. Recovery of plants from the after effects of the treatment was also very slow, because plants were almost burnt, they did not produce flowers and leaves (Fig. 6).

SUMMARY

A multi-direction foliar spray of aqueous F. W. 450 was applied for the induction of male sterility in muskmelon. 0·3% concentration on second spray showed the functional male sterility, while 0·4% concentration with two sprays showed the desired results by inducing pollen sterility. Concentrations of F. W. 450 higher than 0·4% produced deliterious effects.

ACKNOWLEDGEMENTS

We thank ROHM & HAAS Co., Philadelphia 5, PA, U.S.A., for kindly supplying the chemical free of cost, our colleagues for cooperation and Dr. R. K. Singh, Principal, B. R. College, Agra, for facilities.

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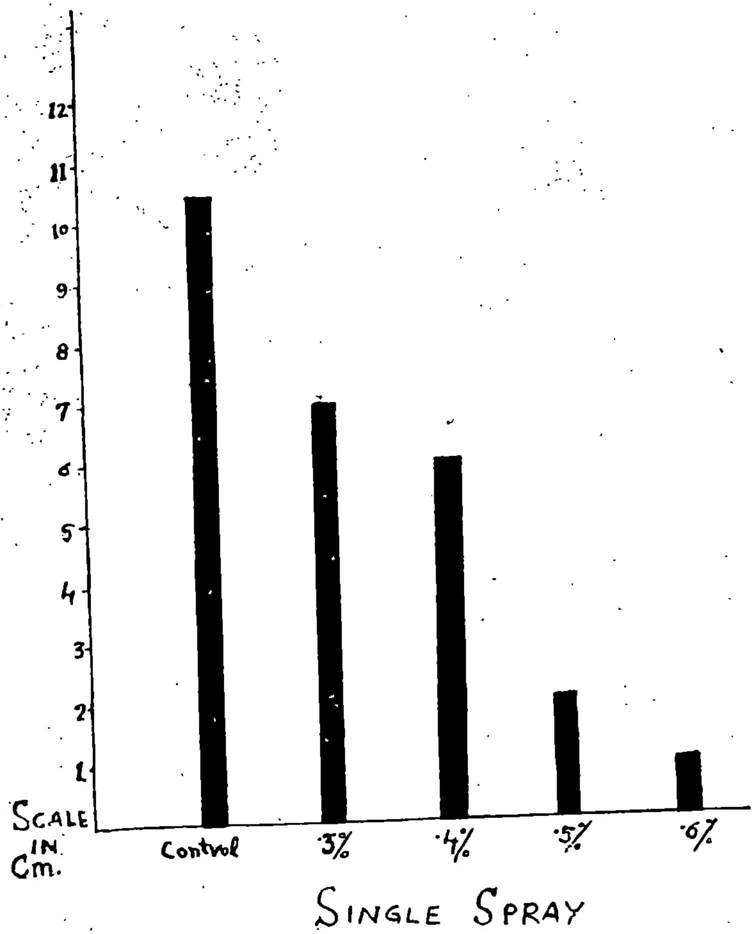
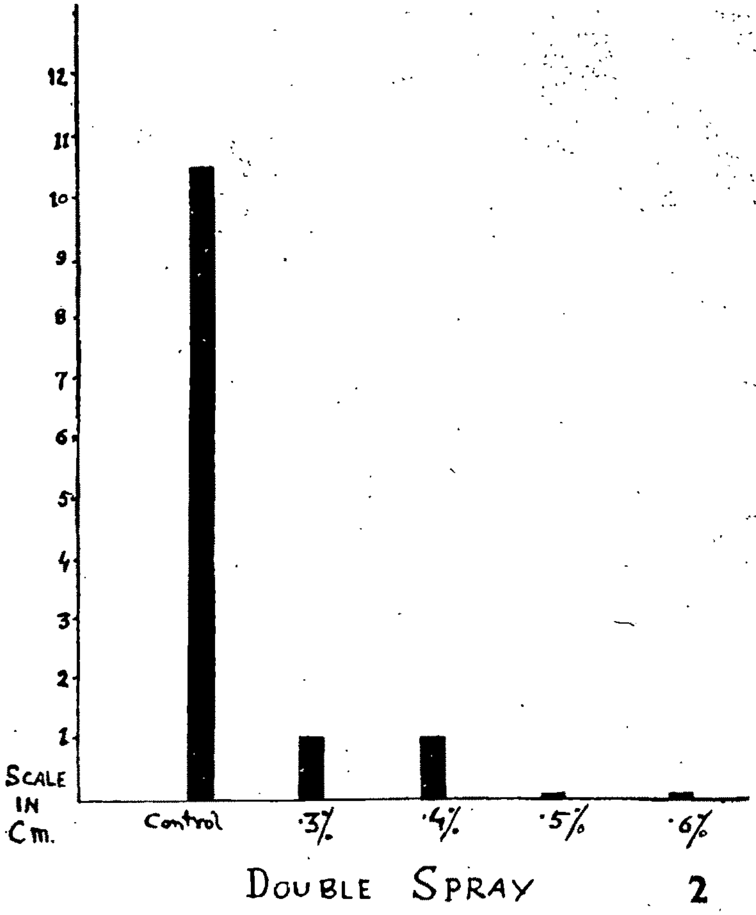
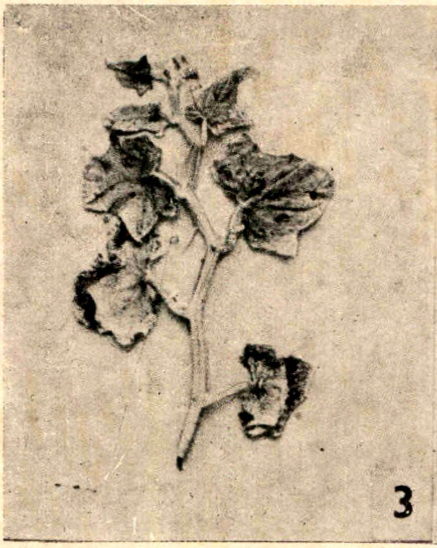


1. Histograms showing the increase of main shoot within 10 days after spray.



2. Histograms showing the increase of main shoot in 10 days treated twice at an interval of 5 days.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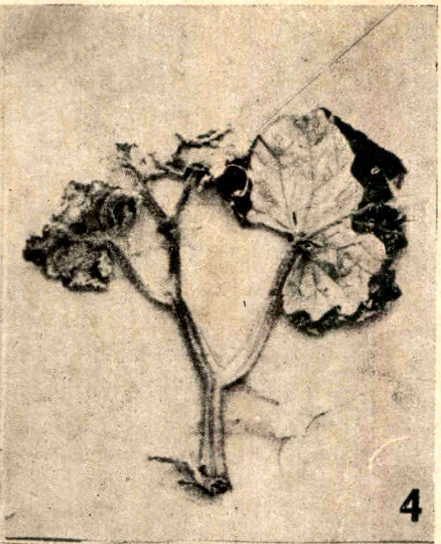
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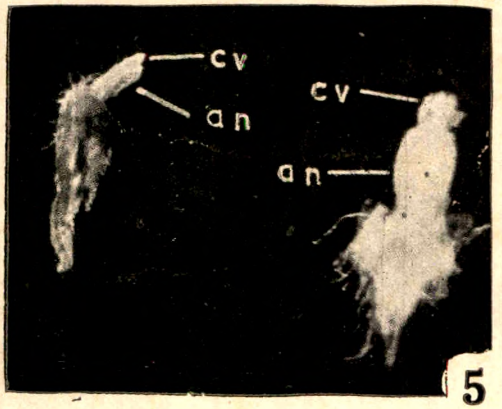

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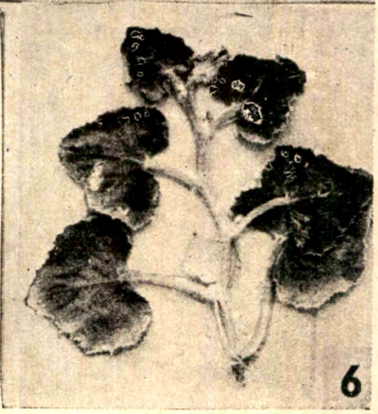
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(*an*—Anther; *cv*—Connective)

3. Plant showing leaf burns on two lower leaves, and yellowing of shoot apex and juvenile leaves.
4. Plant showing extreme damage including leaf burn, shoot burn, and yellowing of the folliage.
5. Stamens in situ; left : treated by 0·4% (B) showing crumpling & shrinking of anther lobes and lack of connective, right : untreated showing quite healthy and fertile anther lobes with prominent connective.
6. Plant showing total damage due to severe burning.

Abstract of Theses

PROTEIN AND NUCLEIC ACID METABOLISM OF SPERMATOZOA (PART I) AND EFFECT OF ACIDS ON SEMINAL AND BLOOD PLASMA PROTEINS AND PURE ENZYMES (PART II)*

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The work reported in this thesis is divided into twelve Chapters. A chapter-wise summary of the thesis is given below.

Chapter I

(1) The genesis, objectives and scope of the present investigation are indicated.

Chapter II

(1) The salient features of the mechanism of protein biosynthesis and its relation to nucleic acid metabolism are discussed briefly.

(2) The reasons for selecting semen as a system for a study of protein and nucleic acid biosynthesis are stated.

Chapter III

(1) The incorporation of (^{32}P)-phosphate, 8-(^{14}C)-adenine, 6-(^{14}C)-orotic acid, 2-(^{14}C)-thymine and 2-(^{14}C)-uracil in suspensions of washed buffalo and bull spermatozoa has been studied. The first three of these precursors, but not thymine and uracil, were incorporated into the total nucleic acids of these spermatozoa. This incorporation is shown to be exclusively into RNA, which was found to be present in these cells in amounts not exceeding 0·02 per cent of their DNA.

(2) Chloramphenicol stimulated the incorporation of (^{32}P)-phosphate, (^{14}C)-adenine and (^{14}C)-orotic acid into washed spermatozoa. Ribonuclease and a mixture of penicillin and streptomycin had no significant effect on this incorporation.

(3) Addition of free amino acids to the incubation medium resulted in a two to three-fold increase in the incorporation of (^{32}P)-phosphate, (^{14}C)-adenine and (^{14}C)-orotic acid into washed spermatozoa.

(4) No significant loss of radioactivity occurred from the nucleic acids on reincubation of washed (^{32}P)-labelled spermatozoa in a medium containing a large excess of non-radioactive phosphate.

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(5) (^{14}C)-orotic acid was found to be incorporated into washed spermatozoa at a much higher rate than in rat testes homogenate.

(6) Seminal plasma inhibited the incorporation of nucleic acid precursors into spermatozoa.

(7) It is suggested that during the incubation of washed bovine spermatozoa, there occurs a net synthesis of a functionally labile RNA.

(8) The investigations reported in this Chapter represent the first systematic study of the nucleic acid metabolism of spermatozoa.

Chapter IV

(1) The incorporation of a mixture of (^{14}C)-amino acids into the proteins of spermatozoa derived from bulls of Indian breed, maintained under local conditions, and the effect of several inhibitors on this incorporation, have been studied and compared with the results of similar investigations carried out earlier.

(2) Washed spermatozoa from buffalo and goat, which contain a normal acrosome, are shown to incorporate radio active amino acids into their proteins. No such incorporation was observed in the case of cock spermatozoa in which the acrosome is either absent or is greatly modified.

(3) The radioactivity of bull and buffalo spermatozoa proteins was retained on reincubation of prelabelled spermatozoa with a large excess of unlabelled amino acids for 1½ hrs.

(4) There was, on an average, a 50 per cent loss of radio-activity from the proteins of bull and buffalo spermatozoa on storage at 0° for 18 hrs, followed by rewarming; this treatment is shown to result in a loss of the acrosome in the following chapter.

(5) The above findings are discussed and it is suggested that the incorporation of radioactive amino acids into the proteins of mammallain spermatozoa occurs in the acrosomal region.

Chapter V

(1) Cold treatment of bull and buffalo spermatozoa at 0° is shown to result in a loss of the acrosome. This observation provides further evidence in favour of the association of hyaluronidase with acrosome in mammals.

(2) Treatment with methanol, of bull and buffalo spermatozoa, incubated with radioactive amino acids, resulted in a release of labelled proteins as well as in a disintegration or a modification of the acrosome. This observation is discussed in relation to the previously reported autoradiographic studies on bull spermatozoa.

(3) In cock spermatozoa, the acrosome is shown to be either absent,

or present in a strongly modified form with properties different from those which characterise mammalian spermatozoa.

(4) It is concluded that the incorporation of labelled amino acids into the proteins of spermatozoa occurs mainly in the acrosomal region.

Chapter VI

(1) The 260 millimicron absorbing material in the acid-soluble fraction of bull, buffalo and goat spermatozoa has been studied. It is shown that practically all of this material consists of purine and pyrimidine derivatives.

(2) The content of purine and pyrimidine derivatives in the acid-soluble fraction was estimated and was found to represent 0·3-1·2 per cent of the dry weight of the spermatozoa.

(3) It is shown that in addition to adenine derivatives, the presence of which had been demonstrated by previous workers, the acid-soluble fraction contains significant amounts of guanine and cytosine derivatives. It is concluded that thymine and uracil derivatives are not present in the acid-soluble fractions of the spermatozoa studied, in more than trace amounts.

(4) The significance of the above observation, particularly in relation to the earlier work on free nucleotides of spermatozoa, is discussed.

Chapter VII

(1) The over-all significance and the possible implications of the findings described in the first part of this thesis (Chapters III-VI) are discussed.

Chapter VIII

(1) The various types of structural modifications which occur naturally and which can be induced artificially in proteins, are reviewed briefly, particularly in relation to the effect of these modifications on biological activity.

Chapter IX

(1) A study has been made of the protein content of bull, buffalo and goat seminal plasma and of the effect of trichloroacetic acid on these proteins.

(2) Precipitation with trichloroacetic acid did not render the seminal sampla proteins insoluble.

(3) The acid-precipitated proteins of bull, buffalo and goat seminal plasma could be resolved into three fractions which were quantitatively estimated. The largest of these fractions was non-dialysable and was soluble in dilute salt solutions; the amino acid composition, the minimum average molecular weight, and the N-terminal amino acids of this fraction from bull, were determined. The second largest fraction was dialysable, and the remaining one as non-dialysable but soluble in water.

(4) There was some change in the relative proportion of the above fractions on storage of semen at room temperature.

(5) Ammonium sulphate fractionation of buffalo seminal plasma proteins gave two fractions with different electrophoretic mobilities; one of these fractions increased at the expense of the other on storage of the semen.

Chapter X

(1) The effect of precipitation by several acids on the solubility and the electrophoretic characteristics of rabbit plasma proteins has been studied. The amount of water-soluble and of salt-soluble proteins in the plasma was not altered on precipitation with 5 per cent perchloric, hydrochloric or nitric acids, followed, in the last two cases, by further treatment with trichloroacetic acid to precipitate the mineral acid-soluble proteins.

(2) Trichloroacetic acid (5 per cent) rendered the salt—soluble protein of plasma (the globulins) water-soluble, without altering their electrophoretic mobility; treatment of the trichloroacetic acid precipitate with 5 per cent sodium chloride, rendered a part of the albumin precipitable at half saturation with ammonium sulphate.

Chapter XI

(1) The effect of precipitation by trichloroacetic acid on the enzymatic and on a few physical properties of crystalline trypsin, pepsin and lysosyme, has been studied.

(2) Pepsin and lysosyme retained their enzymatic activity completely after treatment with trichloroacetic acid and removal of the acid. In the case of trypsin, a slight loss of enzymatic activity was observed.

(3) The heat denaturation rates of the acid-treated lysosyme and pepsin were found to be higher than that of the corresponding native enzyme.

(4) No difference in the electrophoretic mobility of the native and the acid-treated pepsin or lysosyme was detected. The electrophoretic mobility on paper of the acid-treated trypsin was found to be greater than that of the native trypsin.

(5) The significance of the above findings is discussed and it is suggested that a protein could exist in two (or more) structural modifications, the primary structure and the biological activity of which are identical and which differ from one another only in their secondary or/and tertiary structure.

Chapter XII

(1) The over-all significance and the possible implications of the results described in the second part of this thesis (Chapters IX-XI) are discussed.

STUDIES ON THE DISTRIBUTION, FIXATION AND AVAILABILITY OF PHOSPHATES IN SOILS OF SUGARCANE GROWING TRACTS OF BIHAR AND UTTAR PRADESH

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A systematic investigation dealing with distribution, fixation and availability of native and added phosphorus in different types of soils in Bihar and Uttar Pradesh has been undertaken to make some practical suggestions for the judicial use of phosphatic fertilizers for long standing crop like sugarcane.

1. *Distribution of phosphorus in soil profiles of broad soil groups of Bihar and U.P.*

To assess the requirement of a manure or fertilizer for a particular type or group of soils, 13 soil profiles in different soil types of sugarcane belt from Bihar and 14 soil profiles from U.P. were exposed and studied in detail. It has been observed that :

(a) The total phosphorus in most of the soil profiles of the two states decreases with soil depth except in heavy clay soils of Bihar and immature soil of Uttar Pradesh where the total phosphorus increases with depth indicating the effect of parent materials.

(b) In all the soils the major portion of the soil phosphorus is in inorganic form which ranges between 75 to 95 per cent of the total soil phosphorus.

(c) Organic phosphorus in all the soils of Bihar and U.P. is appreciably low indicating poor status of organic matter in these soils.

(d) A distinct difference in pattern of vertical distribution of phosphorus is observed in four different soil groups of Bihar and three soil groups of Uttar Pradesh.

2. *Distribution of available phosphorus at different depths in the profiles and the effect of different soil factors on its availability.*

The soil profiles previously collected were also analysed for organic carbon, nitrogen and phosphorus to find out their mineralization and relationship with each other. It has been observed :—

(a) Organic phosphorus has been found to decrease with the depth of the profile in almost all the soils like organic carbon and nitrogen.

(b) The ratio between organic carbon and organic phosphorus or nitrogen and organic phosphorus decreases with the depth of the profile in most of the soils showing less oxidation of organic phosphorus compared to organic carbon or nitrogen in lower horizons.

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* Abstract of the thesis submitted to the Agra University for the degree of Doctor of Philosophy in Chemistry.

(c) A highly significant correlation is observed between organic carbon, nitrogen and phosphorus in different types of soils in Bihar and some of the soils of Uttar Pradesh.

3. *Fixation and Release of phosphorus in the broad soil groups of Bihar and U. P.*

The periodic decomposition of super phosphate in different types of soils of Bihar and U. P. were studied in pot culture experiment. The results obtained are summarised below :—

(a) The applied soluble phosphate is fixed up in all the soils of the two States within 24 hours and the rate of fixation varies from 32·0 to 52·0 per cent.

(b) The rate of fixation of the applied phosphate increases gradually upto 30-45 days depending on the soil type and thereafter it remains more or less constant with slight fluctuations.

(c) The maximum fixation ranges between 25 to 90 per cent in almost all the soils of Bihar recording as high as 94·0 per cent fixation of the applied P_2O_5 within 120 days incubation.

(d) There is no release of applied or native phosphorus during the incubation period of 120 days.

4. *Availability of phosphorus to plants through application of various forms of readily soluble and partially soluble phosphorus through different phosphatic fertilizers.*

This investigation has been carried out with two alluvial soils, namely calcareous (pH-8·6) from Bihar and non-calcareous (pH 6·8) from U. P. with different phosphatic fertilizers under atmospheric conditions and a fixed moisture level. The results obtained are :—

(a) The decomposition results show better suitability of amorphos in calcareous soils and magnesium phosphate in non-calcareous soils.

(b) Rock phosphate and bone meal are found more suitable for non-calcareous soils.

(*c*) The residual effect of bone meal and rock phosphate is more pronounced in non-calcareous soil compare to calcareous soil.

5. *Release of phosphorus at various levels of soil reactions.*

This study was undertaken to find out the influence of pH on the availability of P_2O_5 in different types of soils. The observations are :—

(a) In non-calcareous and heavy clay soils of Bihar and sub-mature (Type II) soil of U.P., the availability of P_2O_5 slightly increases by increasing or decreasing the pH from their original values.

(b) The calcareous soil of Bihar and immature soil of U.P. show similar behaviour towards the availability of P_2O_5 at different pH. The available P_2O_5 increases with decrease of pH values with buffers.

(c) The availability of P_2O_5 is maximum either in slightly acidic or in slightly alkaline soils.

6. *Mineralization of added organic phosphorus in different types of sugarcane soils of Bihar and U.P.*

This investigation deals with the rate of mineralization of native and added organic phosphorus in different types of sugarcane soils of Bihar and Uttar Pradesh. The following observations have been made :—

(a) The rate of mineralization of added organic phosphorus (sodium phytate) is gradually increased upto 6-8 weeks only in almost all the soils thereafter it remains more or less the same.

(b) The rate of mineralization of the added organic phosphorus is found significantly higher in non-calcareous soils of Bihar and mature soil (Type IV) of U.P., compared to other soils.

(c) The rate of mineralization of both native and added organic phosphorus is high upto 6-8 weeks and then slows down very much. However, the rate of decomposition of added organic phosphorus is much greater than native organic phosphorus.

7. *Comparison of phosphorus in various soil textures.*

This study deals with the distribution of total and organic phosphorus in different particle size fractions of the three main soil associations of Indo-Gangetic alluvium. The results show :—

(a) Total organic phosphorus contents in all the particle size fractions decrease with the maturity of the soils in all the three soil formations.

(b) Clay size fraction contains the maximum amount of total phosphorus and the sand fraction contains the least in most of the soils.

(c) The clay fraction of immature soils of Ganges and Jamna series are rich in total P_2O_5 and are thus better supplier of this nutrient.

(d) The immature soil of some series show a peculiar behaviour where the total as well as organic phosphorus is accumulated around sand particles.

(e) Like total phosphorus, organic phosphorus is also concentrated mostly in clay fraction in most of the soils.

(f) The effect of parent materials is more pronounced in some series of soils but hardly any difference is observed in Ganges and Jamna series soils in respect to distribution of phosphorus in particles size fractions.

The present investigation has furnished a comprehensive picture to the extent to which the behaviour of native and added phosphates in different types of sugarcane soils of Bihar and Uttar Pradesh is affected by various soil characteristics.

STUDIES IN THE CONDENSATION OF AROMATIC ALDEHYDES AND METHYL-ARYL KETONES*

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The thesis consists of nine chapters in all. In the introduction the literature on chalcons has been reviewed.

In the course of present investigations several hitherto unknown aryl-styryl-ketones have been synthesised by the Claisen Schmidt condensation of 2 : 5 dimethoxy-acetophenone with *o*-chloro-, *m*-chloro, *p*-chloro-benzaldehydes; *m*-tolual- and *p*-tolualdehydes; orcacetophenone dimethyl ether with *p*-tolualdehyde, *o*-chloro-, and *p*-chloro-benzaldehydes; 2 : 4-dimethyl-acetophenone with *p*-dimethyl-amino-benzaldehyde; 4-methoxy-2-methyl-acetophenone with *o*-chloro-, *p*-chloro-benzaldehydes; 4-methoxy-5-methyl-acetophenone with *p*-chloro-benzaldehyde; 3-methyl-6-methoxy-acetophenone with *p*-dimethyl-amino-benzaldehyde; 4-aceto-diphenyl with *p*-dimethyl-amino-benzaldehyde; 2 : 4 dihydroxy-benzaldehyde; anisaldehyde, *m*-nitro-benzaldehyde, 2-acetyl-phenanthrene with *o*-veratric, *o*-methoxy-, *m*-methoxy-benzaldehydes, and *m*-tolualdehyde; 3-acetyl phenanthrene with *o*-chloro-, *p*-chloro-benzaldehydes, *m*-hydroxy-benzaldehyde, *p*-methoxy-benzaldehyde; 2-methoxy-1-acetonaphthone, 2-hydroxy-1-acetonaphthone, 1-hydroxy-2-acetonaphthone, and 9-acetyl anthracene with *o*-hydroxy, *m*-hydroxy-, *p*-hydroxy-benzaldehydes; *o*-chloro-, *m*-chloro-, *p*-chlorobenzaldehydes; *o*-nitro, *m*-nitro, *p*-nitro-benzaldehydes; *o*-tolual, *m*-tolual-, *p*-tolualdehydes; *o*-methoxy-, *m*-methoxy-, *p*-methoxy-benzaldehydes; Vanillin; *o*-vanillin; veratric; *o*-veratric; 5-bromo-vanillin; 5-bromo-veratric; *p*-dimethyl-amino-benzaldehyde and furfuraldehyde.

These condensations were carried out at two different temperatures, 0°C and 60°C, in three sets using three different condensing agents *viz.*, potassium hydroxide, sodium hydroxide, and sodium ethoxide. Besides this the influence of molar ratio has also been studied. It has been found that by taking the substituted aryl aldehydes in excess (1·2 : 1 mole) of stoichiometric proportions, the yield increases, while the dismutation of these aryl aldehydes into a mixture of substituted benzyl-alcohol and substituted benzoic acids according to Cannizzaro's reaction also increases. Thus a critical study of the factors influencing the yield, with a view to determine the optimum conditions for the syntheses, has been made. The methyl aryl ketones required in the syntheses of these compounds, have been prepared by the author. Characterisation of aryl-styryl-ketones has been done by the preparation of their 2 : 4 dinitrophenylhydrazone. Flavanones have been synthesised by the acid isomerisation of appropriate aryl-styryl-ketones. These have been identified by the characteristic colour which they develop when their alcoholic solution are reduced with magnesium and concentrated hydrochloric acid.

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* Abstract of the thesis submitted to Agra University for the degree of Doctor of Philosophy

In this way more than two hundred compounds have been synthesised and are being reported for the first time.

The condensation of beta-aceto-naphthone (1 mole) with *m*-tolualdehyde (2 moles) in presence of strong alkali leads to the formation of 3-methyl qenzylidene diacetonaphthone. The mechanism of the formation of the latter compound has been suggested. Effect of substituents in different positions in benzaldehyde molecule, and in methyl-aryl-ketone and the influence of the condensing agents has been discussed.

Aryl-hydroxy-styryl ketones—In the condensation of hydroxy benzaldehydes with methyl-aryl ketones in the presence of alkali a side reaction *viz.*, Cannizzaro's reaction, was found to take place specially at 60° C, along with the formation of resin and aryl-hydroxy-styryl ketones. Optimum conditions have been established for their syntheses to give a maximum yield of the desired compound.

Aryl-methoxy-styryl ketones—In general it was found that yield in condensations with methoxy benzaldehydes could be obtained in a much higher than with the corresponding hydroxy-benzaldehydes. Acid isomeration of aryl-methoxy-styryl ketones resulted in the formation of the corresponding flavanone in case of molecules having hydroxy group adjacent to the carbonyl group.

Aryl-methyl-styryl ketone—The Claisen Schmidt condensation of methyl-aryl ketones with isomeric tolualdehydes at 0° C, for half an hour and finally at room temperature for 36 hours has proved advantageous over the condensation affected at 60°C, because of increased yield of aryl-methyl-styryl ketones and decreased resin formation. The isomerisation of aryl-methyl-styryl ketones into their flavanones has been found to proceed smoothly and the flavanones have been obtained in good yield. In the compounds having hydroxyl group, situated in ortho position to the carbonyl group, the effects of various factors, *viz.*, reaction time, temperature solvent, and the influence of ratio on the yield of these compounds have been studied.

Aryl-halogensubstituted styryl ketones—The relatively higher yield of these compounds has been explained from the stand point of modern electronic theory *i.e.*, on the basis of inductive and direct effects. On acid isomerisation, the aryl-halogen substituted styryl ketones readily yield their corresponding flavanones.

Aryl-nitro-styryl ketones—The condensation of nitro-benzaldehydes with methyl aryl ketones seems to take an abnormal course. In the case of ortho-nitro-benzaldehyde the probable course of reaction has been outlined.

The syntheses of these compounds have been carried out by using a specific volume of the solvent, employing a specific concentration of alkali as condensing agent, at 0° C. In this manner the resinification and the formation of other side reactions have been minimised.

Physico-chemical studies—(a) This section deals with the infra-red studies in fifteen similar aryl-styryl-ketones. The characteristics of carbonyl frequencies have been discussed.

(b) During the Claisen condensation of aromatic aldehydes with methyl aryl ketones, it was found that two classes of products are formed depending upon the experimental conditions. The products in one case are aryl-styryl ketones, while in other case are the products of Cannizzaro's reaction *viz.*, substituted benzyl alcohols and substituted acid.

It appeared also of value to carry out studies on ionization constant of veratric and vanillic acid. The data on this subject are scanty in literature and the results are of interest from the stand point of substituent effects.

The pK value for the ionisation of the carboxyl group have been determined pH metrically at different temperatures. The variation of pK with temperature has been found to obey an equation of the type of Harned and Robinson.

From the parameters of this equation the thermodynamic functions of ionisation such as change in free energy, entropy heat content and heat capacity have been computed. The influence of the substituents on the ionisation of the parent acids has been discussed and the applicability of the free energy aciditivity relationship has been examined. The consideration of the entropy of ionisation has indicated that no significant energy differences are involved in the molecule solvent and anion-solvent interactions.

ACTION OF DIAZOMETHANE AND OF SUBSTITUTED DIAZOMETHANES ON ACID CHLORIDES OF CARBOXYLIC ACIDS*

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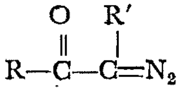
The present work was taken up with an aim to synthesise diazoketones from carboxylic acid chlorides containing one or more sites of reactivity towards diazomethane and substituted diazomethanes and to study, with reference to molecular structure, the type of changes which the above diazoketones undergo, under different conditions like temperature, nature of medium and that of the attacking reagents.

The diazoketones described in the thesis are of the type (I) (containing the diazo group in the α-position with respect to the carbonyl group).



$$R-\overset{\overset{O}{\|}}{C}-\overset{\overset{R'}{|}}{C}=N_2$$

(I)

The method of Robinson and Bradley (J. Chem. Soc., 1310, 1928) was used for the synthesis of the following diazoketones by the action of diazomethane and that of diazoethane on acid chlorides containing only one site of reactivity towards them :—

ω-Diazo-acetophenone (II; I, $R=C_6H_5$, $R'=H$), α-diazo-$\alpha'\alpha'$-diphenyl-acetone (III; I, R=diphenyl methyl, $R'=H$), ω-diazo-m-nitro-acetophenone (IV; I, $R=m\text{-}NO_2\text{-}C_6H_4=$, $R'=H$), ω-diazo-m-chloro-acetophenone (V; I, $R=m\text{-}Cl\text{-}C_6H_4\text{-}$, $R'=H$), ω-diazo-o-methoxy-acetophenone (VI; I, $R=o\text{-}MeO\text{-}C_6H_4\text{-}$, $R'=H$), α-diazo-α'-benzyl-acetone (VII; I, $R=C_6H_5\text{-}CH_2\text{-}CH_2\text{-}$, $R'=H$), ω-diazo-ω-methyl-o-methoxy acetophenone (VIII; I, $R=o\text{-}MeO\text{-}C_6H_4\text{-}$, $R'=Me$), ω-diazo-ω-methyl-o-acetoxy-acetophenone (IX; I, $R=o\text{-}AcO\text{-}C_6H_4\text{-}$, $R'=Me$). The diazoketones (IV), (V), (VII), (VIII) and (IX) were prepared for the first time. A method for estimation of diazo group, in the diazoketones by decomposing them with HCl and collecting the nitrogen evolved, has been described. The new diazoketones have been characterised by estimation of elements and the action of certain reagents on them (see later).

In Robinson and Bradley's method (loc. cit.) for the preparation of diazoketones an excess of diazomethane (2·5 mols.) is used, per molecule of an acid chloride, to consume hydrogen chloride evolved. Thus a molecule of diazomethane is wasted. Newman and Beal (J. Am. Chem. Soc., **71,** 1906-1907, 1949) avoided this wastage of diazomethane by using tertiary bases like triethyl-amine to consume the hydrogen chloride evolved during the reaction. They obtained diazoketones, from aromatic acid chlorides in good yields but failed to obtain diazoketones with aliphatic acid chlorides (containing α-hydrogen atom). It is well known (Adkins and Thompson J. Am. Chem. Soc., **71,** 2242, 1949) that acid chlorides also react with tertiary bases to form labile addition products and when the acid chlorides with α-hydrogen atom are used dehydrohalogenation takes places (Staudinger, Ann., **356,** 51, 44, 1619-1623, 1911). No mention has been made, of the behaviour of tertiary bases with acid chlorides, by Newman and Beal (loc. cit.). It seems that they have ignored this aspect which is important in the reaction. It has been found that the addition products react with diazomethane forming diazoketones. A probable mechanism for the role of tertiary bases, in this reaction, has been proposed.

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It is well known that diazomethane is not only susceptible to the acid chloride group but also reacts with a double bond (Azzarello Atti, Accad. Lincei, **14,** II, 235, 1905), a phenolic group (Von Pechmann, Ber., **28,** 857 1895; *ibid*, **31,** 501, 1898) or a carbonyl group (Meerwein and others, Ber., **61,** 1840, 1928; *ibid*, **62,** 999, 1929).

Thus by treating acid chlorides containing two sites of reactivity towards diazomethane and substituted diazomethanes, it is possible to affect either one or both sites using different amounts of diazomethane and of diazoethane resulting in the formation of different diazoketones. With this aim in view the author attempted the action of different amounts of diazomethane and of diazoethane on unsaturated, phenolic and carbonyl acid chlorides.

Diazoketones from unsaturated acid chlorides :

Cinnamoyl chloride (1 mol.) when treated with different amounts of diazomethane (2·5 or 4 mols.) always resulted in the formation of a mixture of 4-phenyl-3-diazo-acetyl Δ^{-2}-pyrazoline and 1-diazo-4-phenyl-3-butenone (X; I, $R=C_6H_5-CH=CH-$, $R'=H$). The formation of (X) as described above suggests that the acyl chloride group is more susceptible, towards the action of diazomethane than the double bond. It was found that diazoethane behaved in a similar way. As characterisation of 4-phenyl-3-diazo acetyl Δ^{-2}-pyrazoline could not be accomplished, so the action of 4 mols. of either diazomethane or diazoethane on $\alpha\beta$-unsaturated acid chlorides was not further attempted.

The followng new diazoketones with the exception of (X) were prepared by the action of diazomethane and of diazoethane (each 2·5 mols.) on $\alpha\beta$-unsaturated acid chlorides.

1-Diazo-4-phenyl-3-butenone (X), 1-diazo-4-phenyl 3-bromo-3-butenone (XI; I, $R=C_6H_5-CH=CBr-$, $R'=H$) and 1-diazo-1-methyl-4-phenyl-3-butenone (XII; I, $R=C_6H_5-CH=CH-$, $R'=Me$). They were also characterised by the estimation of elements and by the action of certain reagents on them (see later).

Diazoketones from phenolic acid chlorides :

It was found that the action of diazomethane (2·5 or 4 mols.) on salicyl chloride (1 mol.) results in the formation of a mixture of ω-diazo-o-hydroxy acetophenone (XIII; I, R=o-HO-C_6H_4-, R′=H) and ω-diazo-o-methoxy acetophenone (VI), separable by 1% NaOH solution (Kapoor and Gupta, J.I.C.S., **38,** 776-778, 1961). The formation of a mixture of (XIII) and (VI), suggests that the acid chloride group is more susceptible, towards diazomethane, than the phenolic group.

The following new diazoketones with the exception of (VI) and (XVI) were synthesised.

ω-Diazo-o-hydroxy-acetophenone (XIII), ω-diazo-o-methoxy-acetophenone (VI), ω-diazo-p-hydroxy acetophenone (XIV; I, R=p-HO-C_6H_4-, R′=H), ω-diazo-p-methoxy acetophenone (XV; I, R=p-MeO-C_6H_4-, R′=H), ω-diazo-m-hydroxy acetophenone (XVI; I, R=m-HO-C_6H_4-, R′=H) and ω-diazo-m-methoxy acetophenone (XVII; I, R=m-MeO-C_6H_4-, R′=H). These with the exception of (XVI and XVII) were characterised by the action of certain reagents on them (see later).

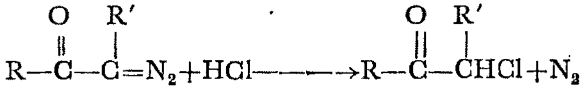
Diazoketones from carbonyl acid chlorides :

As diazomethane is likely to be more susceptible towards the acid chloride group than the carbonyl group, it is possible to obtain a diazoketone (using 2·5 mols. of diazomethane) in which the carbonyl group remains intact. With this aim in view the action of diazomethane (2·5 mols.) was carried out on benzoyl formyl-chloride when diazomethyl-benzoyl-ketone (XVIII; I, R=C_6H_5-CO-, R′=H) was obtained. It could not be purified and failed to undergo Arndt-Eistert Synthesis (Ber., **68,** 204, 1935). However, it gave a tri-2 : 4 dinitro-phenyl hydrazone when treated with aqueous alcoholic sulphuric acid solution of 2 : 4 dinitrophenyl hydrazine.

The diazo group in the diazoketones is unstable and nitrogen is lost readily by heat with or without a catalyst and also by an attack of a reagent, leaving behind a radical which is more unstable than the diazoketone itself. This then tends to stabilise itself by a variety of reactions (Wolff, Ann., **394,** 23, 1912; cf. Staudinger, Becker and Hirzel, Ber., **49,** 1978, 1916; Bradley and Robinson, J. Chem. Soc., 1928, 1541; Seth and Deshapande, J.I.C.S., **29,** 539-542, 1952; Arndt and Eistert, loc. cit.; King and Miller, J. Am. Chem. Soc., **71,** 367-368, 1949; Yates and Shapiro, J. Am. Chem. Soc., **81,** 212-217, 1959; Canorica, Gazz. Chim. ital., **80,** 412-425, 1952; Bose and Yates, J. Am. Chem. Soc., **74,** 4703-4704, 1952; Palit and Chaterjee, Science and Culture, **17,** 345, 1952) such as polymerisation, addition, rearrangement and cyclisation. The action of some new and already worked reagents was studied, on diazoketones already described. These reagents may be classified in the following groups according to the nature of the attacking reagent as well as the radical produced by the elimination of nitrogen :—

(1) *Reagents which add to the radicals produced by elimination of nitrogen from the diazoketones:*

(a) *Action of hydrogen halides on diazoketones*—Hydrogen chloride reacts with diazoketones forming chloromethyl ketones (XIX) (Wolff, loc. cit.; Kapoor, Gupta and Gupta, Agra Univ. Jour. Res., **10**, 1-6, 1961).



$$R-\overset{\overset{\displaystyle O}{\|}}{C}-\overset{\overset{\displaystyle R'}{|}}{C}=N_2+HCl \longrightarrow R-\overset{\overset{\displaystyle O}{\|}}{C}-\overset{\overset{\displaystyle R'}{|}}{C}HCl+N_2$$

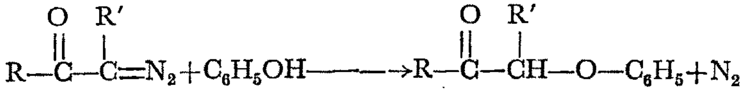
(I) (R'=H) (XIX)

Chloromethylketones were prepared from diazoketones (II), (III), (IV), (V), (VII), while (X) and (XII) remained unaffected.

(b) *Action of phenol on diazoketones*—This is a new reagent attempted for the first time. Its action was carried out with the diazoketones, in two ways as under :—

(i) Diazoketones were treated with molten phenol and the mixture heated on a flame till the evolution of nitrogen ceased. Acyl-methyl-phenyl-ethers (XX) were obtained by treating the reaction mixture with NaOH solution followed by extraction with ether and evaporation of the solvent.

(ii) The action of phenol was carried out in presence of copper powder when similar results were obtained at a lower temperature.

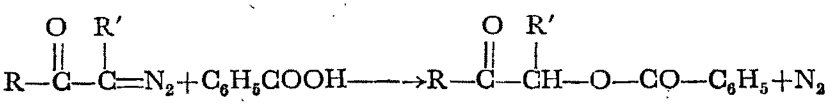


$$R-\overset{\overset{\displaystyle O}{\|}}{C}-\overset{\overset{\displaystyle R'}{|}}{C}=N_2+C_6H_5OH \longrightarrow R-\overset{\overset{\displaystyle O}{\|}}{C}-\overset{\overset{\displaystyle R'}{|}}{C}H-O-C_6H_5+N_2$$

(I) (R'=H) (XX)

The above reaction was carried out with diazoketones (II), (III), (IV), (V), (X), (XI) and (XVIII).

(c) *Action of benzoic acid on diazoketones*—It was found that the action of molten benzoic acid with diazoketones resulted in the formation of the benzoyl derivative of the corresponding hydroxymethyl ketones (XXI).

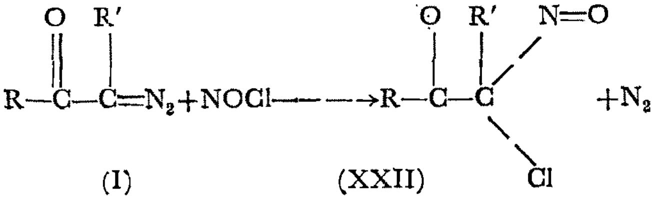


$$R-\overset{\overset{\displaystyle O}{\|}}{C}-\overset{\overset{\displaystyle R'}{|}}{C}=N_2+C_6H_5COOH \longrightarrow R-\overset{\overset{\displaystyle O}{\|}}{C}-\overset{\overset{\displaystyle R'}{|}}{C}H-O-CO-C_6H_5+N_2$$

(I) (R'=H) (XXI)

This reaction was attempted on the diazoketones (II), (III), (IV), (V), (X) and (XVIII).

(d) *Action of nitrosyl chloride on diazoketones*—Diazoketones on treatment with nitrosyl chloride in dry benzene at 0° C gave nitrosochloroketones (XXII) (Seth and Deshapande, loc. cit., Kapoor, Gupta and Gupta, loc. cit.).



(I)
(R'=H)
(XXII)

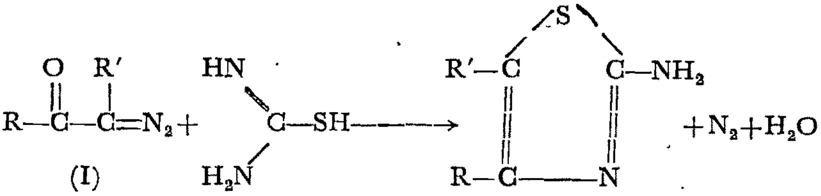
This reaction was carried out with diazoketones (III), (IV), (V) and (VII).

(2) *Reagents which add to the radicals produced by elimination of nitrogen from diazoketones after undergoing Wolff Rearrangement (Arndt-Eistert Synthesis) :*

Arndt-Eistert Synthesis (loc. cit.) was carried out to establish the identity of diazoketones (III), (IV), (V), (VI), (VII), (VIII), (IX), (X), (XI), (XII), (XIII), (XIV), (XV), (XVI), (XVII and (XVIII) but it was not successful in diazoketones (VIII), (IX), (XI), (XV), (XVI), (XVII) and (XVIII).

(3) *Reagents which add to the radicals produced by elimination of nitrogen from diazoketones and resulting addition product undergoing cyclisation :*

Diazoketones, on treatment with thiourea, form the corresponding 2-amino 4-alkyl (or aryl)-thiazoles (XXIII) (King and Miller, loc. cit.; Kapoor, Gupta and Gupta, loc. cit.).



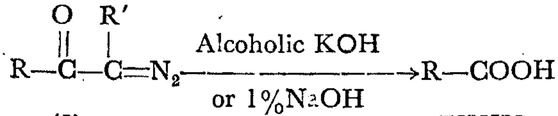
(I)
(R'=H)
(XXIII)

No mechanism has been put forward by King and Miller (loc. cit.) regarding the formation of thiazoles from diazoketones. A probable mechanism has been discussed in the thesis.

This reaction was carried out with diazoketones (III), (IV), (V) and (VII).

(4) *Decomposition of the diazoketones by alkali :*

Diazoketones, on decomposition with alkali gave alongwith other materials the acid (XXIV) whose chloride formed the diazoketones (Yates and Shapiro, loc. cit.). The action of alcoholic KOH or 1% NaOH was carried out to establish the presence of a double bond, and a phenolic group in the diazoketones (Kapoor and Gupta, loc. cit.).



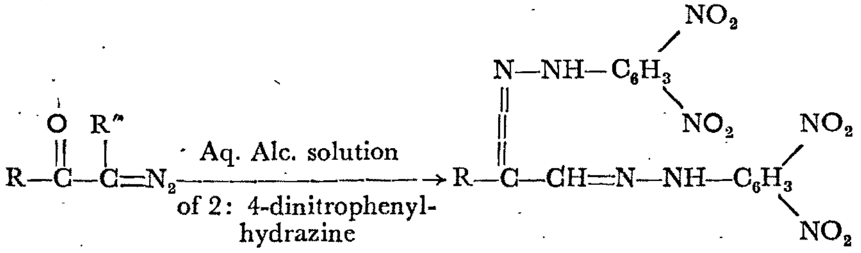
$$\mathrm{R{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}\overset{\overset{\displaystyle R'}{|}}{C}{=}N_2} \xrightarrow[\text{or } 1\%\text{NaOH}]{\text{Alcoholic KOH}} \mathrm{R{-}COOH}$$

(I) (R'=H) (XXIV)

This reaction was attempted on the diazoketones (X), (XI), (XII), (XIII), (XIV), (XV), (XVI) and XVII).

(5) *Action of* 2 : 4-*dinitrophenyl-hydrazine on diazoketones :*

Canorica (loc. cit.) reported the formation of either the phenyl osazone of the corresponding phenyl glyoxal or the phenyl hydrazide of an acid or a mixture of both of them. It was found, that the action of 2 : 4-dinitrophenyl-hydrazine, on diazoketones in aqueous alcoholic sulphuric acid solution gave the corresponding aryl-glyoxal-2 : 4-dinitrophenyl osazones (XXV). The acid 2 : 4-dinitrophenyl hydrazides were not formed in the reaction. A mechanism of the reaction has been proposed. As the derivatives were formed, almost instantaneously, so it was found to be a good reagent for identifying diazoketones. The action was attempted in case of diazoketones (II), (IV), (V), (X), (XI) and (XVIII) when solid osazones (XXV) were obtained in each case.



$$\mathrm{R{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}\overset{\overset{\displaystyle R''}{|}}{C}{=}N_2} \xrightarrow[\text{of 2: 4-dinitrophenyl-hydrazine}]{\text{Aq. Alc. solution}} \mathrm{R{-}\overset{\overset{\displaystyle N{-}NH{-}C_6H_3(NO_2)_2}{\|}}{C}{-}CH{=}N{-}NH{-}C_6H_3(NO_2)_2}$$

(I) (R'=H) (XXV)

(6) *Decomposition of diazoketones by acids in whose presence the radicals produced undergo cyclisation :*

The diazoketones (VI), (VIII), (IX) and (XIII) were found to be quite stable at room temperature and did not undergo spontaneous decomposition (cf. Seth and Deshapande, loc. cit.; Bose and Yates, loc. cit.).

The diazoketone (VI) on treatment with dilute sulphuric acid gave coumaranone identified by its m.p. and formation of semicarbazone (m.p. 220° C). The same semicarbazone was obtained when (VI) was directly treated with semicarbazide hydrochloride and sodium acetate.

Similarly, (VIII) and (IX) on treatment with dilute sulphuric acid gave 2-methyl coumaranone. It gave a semicarbazone (m.p. 234° C) which was found to be identical with that obtained directly from the two diazoketones. (Kapoor, Kapoor and Gupta, Agra Univ. Jour. Res., **9**, 323-325, 1960).

The sodium compound of (XIII) also forms coumaranone, when treated with dilute hydrochloric acid, identified as before (Kapoor and Gupta, loc. cit.).

STUDIES ON THE STRUCTURE, DEVELOPMENT, INNERVATION AND PHYLOGENY OF THE HEART AND ITS CONDUCTING TISSUE IN BAT, PIGEON AND RABBIT*

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Many of the early investigators (Willis 1616-64 and others) had held the view that the cardiac nerves are responsible for impulse initiation and conduction. Later investigators (Haller 1762; Engelmann 1875, '78, '94, '95, '97 and 1903; Gaskell 1882, '83, and 1900; MacWilliam 1885; His Jr. 1893; Tawara 1906; Keith and Flack 1907; Lewis 1915 and many others) opposed this conception and brought forward sufficient evidence to show that the impulse initiation and conduction is the inherent property of the heart muscle itself. Recently a few authors (Glomset & Birge 1948) have denied the presence of any specialized muscular conduction system in the heart of birds and mammals. The investigators of the twentieth century (Keith & Flack 1907) believed that the specialized impulse initiating and conducting structures of the heart of homoiothermal vertebrates are remanents of more extensive tissues of similar nature found in the heart of poiklothermal vertebrates while Davies & Francis 1946 have held the view that these structures are neomorphic in nature. According to a very lately advanced view (Prakash 1953, '54, '56, '57 and '60; Bhatnagar 1957 and Jain 1960) these structures have evolved from and are further specializations of the tissue already existing for the purpose in the heart of lower vertebrates.

To compare the nature, development and phylogeny of the specialized conducting structures, studies on the anatomy of the conducting tissue of the heart of bat appeared essential because the bat, though a mammal, is adapted for active flight and these observations have been compared with those of the heart of pigeon and rabbit. To understand the different aspect of the problem of conduction in their over all significance, the finding of the previous investigators have been discussed in light of the results obtained from the present study and are presented as an integrated unit. The presence of nerves and ganglia in the heart, particularly in muscular conduction system, has also been ascertained as a few investigators have paid attention to this aspect of the problem.

HEART

In the heart of 12·5 mm. bat embryo and 20 mm. embryo of pigeon it was observed that atrium, atrioventricular canal and ventricle have started the division while the bulbus remains distinctly undivided. The right sinuatrial valve and the right valve of the postcaval meet dorsally and form the septum spurium. The septum primum grows towards the atrioventricular endocardial cushions. This septum breaks near the atrial wall where it first appeared, to form the foramen secundum and the septum secundum which though appears as a small outgrowth gradually elongates and hangs into the right atrial cavity as the development proceeds. It is histologically like the septum primum. Thus in the heart of 12·5 mm. embryo of bat both the foramina primum and secundum are present in between the two atria. This arrangement is suggestive of the fact that at very early stage of development the left atrium depends solely on the right atrium for its blood supply and the appearance of foramen secundum in the presence of foramen primum provides an additional passage for the flow of blood to the left atrium. In the succeeding stages of development the foramen primum becomes totally obliterated due to the direct attachment of the septum primum with the atrioventricular endocardial cushions and the foramen secundum remains the only passage of communication between the two atria. This presumably takes place to keep the interatrial balance as the left atrium simultaneously starts receiving pulmonary flow. In the heart of embryos the free end of the septum primum at the foramen ovale is bent towards the left atrium and the opening of the postcaval is placed near the foramen ovale. Such an arrangement clearly shows that a major part of the blood poured by the postcaval into the right atrium would be sent directly into the left atrium through the foramen ovale.

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* Abstract of the thesis submitted to Agra University for the degree of Doctor of Philosophy.

In both bat, and pigeon the right atrioventricular valve develops on similar lines and gradually becomes highly muscular. The presence of such a highly developed valve in the heart of bat may be correlated with its flying habit like birds.

CONDUCTING TISSUE

All the conducting structures are distinct in the heart of adults though they appear at different stages of development in different animals. The differentiation of specialized tissue commences in bat at 12·5 mm., in pigeon at 20 mm. and in rabbit at 45 mm. The sinuatrial node is the first constituent of the conducting system to appear in the heart of these animals. In bat and rabbit the atrioventricular bundle appears after the sinuatrial node and is followed by the atrioventricular node, however, in pigeon the sinuatrial node is followed by atrioventricular node and atrioventricular bundle which appear simultaneously.

The sinuatrial node appears and becomes quite a conspicuous and distinct structure before the absorption of the sinus venosus into the right atrium. It is apparent that the node develops independent of the reduction of the sinus venosus. The disposition of the node may be correlated with the reduction of the sinus venosus, as the node first appears dorsal to the sinuatrial opening but gradually moves into the dorso-cranial wall of the right atrium in between the sinuatrial opening and the base of the interatrial septum as the development proceeds and the sinus venosus becomes gradually absorbed into the right atrium. In the heart of adult bat, pigeon and rabbit where the sinus venosus is absent, this node was found to be present invariably near the base of the interatrial septum towards the opening of superior venacava. Constituent fibres of the sinuatrial node are continuous with the atrial musculature. Sinuatrial node is a compact mass of irregularly anastomosed strands which appear as Purkinje fibres with prominent nuclei placed within the clear cytoplasm. Numerous spherical and closely placed transparent granules are abundantly present in the node. The myofibrillae of the nodal fibres in the centre are sparse and regularly placed but are concentrated near the periphery. The disposition of sinuatrial node shows that the impulses from the sinuatrial node would be conducted to the right atrium directly. However, in the heart of pigeon the node is connected directly through the Purkinje fibres with the interatrial septum on one hand and left sinuatrial valve on the other. Such an arrangement may account for the quicker transmission of the contraction stimulus from sinuatrial node to the atria in the faster beating avian heart.

The late appearance of atrioventricular node in the heart of embryos of bat and rabbit may be correlated to comparatively slower rate of heart beat as the presence of atrioventricular node would cause the unnecessary atrioventricular pause. In the heart of embryos of pigeon the heart beat is presumably faster, as such the presence of an atrioventricular node is essential to cause the necessary atrioventricular pause, so that the ventricles get enough time for expansion and receiving the blood from the atria. In the heart of pigeon the atrioventricular node is comparatively poorly developed and ill defined than that of bat and rabbit, both in the developmental stages and in the adult. As the development proceeds the atrioventricular node in the heart of pigeon becomes gradually less distinct and in the adult it is poorly defined. In case of bat and rabbit it is vice versa and in adult this node is quite a distinct structure. In the heart of rabbit this node is comparatively more developed and extensive than that of bat. The gradually reduction in size and differentiation of the atrioventricular node in the heart of pigeon may be correlated with fast rate of heart beat. The atrioventricular node in this animal being poorly developed would cause less delay in transmitting the atrial wave of contraction to the ventricles. In bat and rabbit this node being well developed would transmit the cardiac stimulus of contraction to the atrioventricular bundle after the necessary pause required by the ventricles to get ready to receive blood from the atria. Bat, a mammal adapted for active flight needs comparatively quicker transmission of contraction stimulus than rabbit. To meet this requirement the atrioventricular node in this animal is less developed than rabbit, hence would cause less delay in the transmission of the impulse to the atrioventricular bundle. In this feature the heart of bat is more near to that of pigeon. The atrioventricular node is continuous proximally with the muscles of the interatrial septum and distally with those of the atrioventricular bundle. A nodal artery traverses the atrioventricular node in the heart of embryos and adult pigeon.

A distinct atrioventricular bundle has been observed in all the animals studied. In the heart of bat several fine branches are given off from the base of the atrioventricular bundle. The right limb subdivided into two branches one of which enters the base of the right atrioventricular valve while other descends along the right border of the interventricular septum. Similarly the left branch also gives off a branch to the left atrioventricular valve and then continues down into the interventricular septum of its own side. In pigeon the distribution of the atrioventricular bundle and its branches is the same as in bat. However, in rabbit a different course of the bundle and its branches is observed. In this animal the right branch immediately after its origin from the main bundle divides into a thinner and a thicker branch. The thinner branch goes into the right atrioventricular valve and the thicker radiates by several branches into the middle portion of the interventricular septum. The left branch, however, has the same course and distribution as in bat and rabbit. The extensive distribution of the right bundle branch in the right atrioventricular valve and the right side of the interventricular septum in the heart of bat and pigeon is a unique feature hitherto not observed. Such an arrangement may be correlated with the functional requirements of the heart of these animals, presumably due to the rapid rate of heart beat. Regarding the conducting tissue, the heart of bat is more closely related to the pigeon. The left bundle branch develops before the right in the heart of embryos. This may be co-related to the subsequent greater functional importance of the left ventricle.

Purkinje fibres were observed in the conducting tissues at quite an early stage of development. These fibres develop in situ and form the integral constituent of the specialized conducting tissues and hence are conducting in function. Direct tracts of specialized tissue (Purkinje fibres) are absent in the heart of mammals (bat and rabbit) but in bird (pigeon) a continuous tract of Purkinje fibres was observed to extend from the sinuatrial node to the interatrial septum and onwards to the atrioventricular node along the right margin of the interatrial septum.

INNERVATION

The cardiac nerve supply is both from the sympathetic and the parasympathetic components of the autonomic nervous system. The sympathetic nerve supply to the heart, on either side, is from superior cervical sympathetic cardiac nerve, middle cervical sympathetic cardiac nerve and inferior cervical sympathetic cardiac nerve. In bat and rabbit the thoracic cardiac nerves arise from first to fourth thoracic sympathetic ganglia, whereas in pigeon their origin is limited only to first and second. The parasympathetic nerve supply is from the vagi which give off branches both in the neck and the thorax. This parasympathetic contribution is from the superior, middle and inferior groups of vagal cardiac nerves on either side. In bat and pigeon each of these three groups consists of two filaments arising from the vagus but in rabbit the superior group has two branches of vagus while middle and inferior have three each. The nerves descending into the heart from the right and the left side of the cardiac plexus, supply the corresponding portions of the heart. Some of the nerve fibres from the cardiac plexus are supplied to the adjucent major blood vessels while the others descend into the heart along with the coronary arteries of their side. On the surface of the heart these nerve fibres form a right and a left coronary plexus around the coronary vessels of their side. From these plexuses, coronary nerve branch and ramify in the subepicardial tissue of the heart. A few extrinsic cardiac ganglia are present in relation to superior and inferior venacava, aortic and pulmonary arches and dorsal atrial wall. The intrinsic cardiac ganglia were located in the subepicardial and myocardial tissue of the heart. The largest intrinsic ganglion is present at the atrioventricular sulcus. Both the dark stained and the pale stained ganglia are distinctly present. The majority of nerve cells in these ganglia are bipolar, a few unipolar while the multipolar cells are less common. The cells met within the cardiac ganglia are of one type only *i.e.*, large, round or oval with considerable amount of granular cytoplasm.

The left atrium is comparatively poorly innervated. Many nerve fibres are present in the wall of the right atrium at the sulcus terminalis, sinuatrial opening and also extend into the sinuatrial valves. The dorsal surface of the atria is more profusely innervated than their ventral surface. In the embryo of bat a few nerve ganglia are present on the dorsal aspect of the pericardium. In the interatrial septum the ganglia and the nerves are present at its craniodorsal end, embedded in its muscle bundles and near its caudal end. A ganglion is present burried between the right lateral atrial and ventricular myocardium but subendocardial ganglia are absent. A unique feature, so far not recorded, is the presence of nerves and ganglia in relation to the right and left atrioventricular valves. In bat and rabbit the ganglia and the nerves are present at the bases of these valves while in pigeon fine nerve fibres are traced deep into the substance of these valves. Nerve fibres are also present at the bases of the semilunar valves of the pulmonary arch. Besides the subepicardial ganglionic cells, the ventricles are also supplied by nerve fibres descending from the ganglia of the atrioventricular sulcus and by coronary nerves running in the epicardium specially at the interventricular septum towards its cranial side. In pigeon the ventricles are comparatively richly innervated than bat while in rabbit the ventricular nerve supply is poor. Several fine nerves and isolated nerve cells were observed at the pars membrancea septi. It is noteworthy that in the heart of bat the infundibulum is richly supplied by ganglia and nerve cells. The nerve fibres, becomes gradually thin and end abruptly.

The nervous elements make their appearance in the heart only after the conducting tissue has appeared. In bat the conducting tissue appears at 12·5 mm. while nervous elements at 30 mm. In pigeon conducting tissue at 20 mm. and the nerves at 55 mm. and in rabbit both these structures appear at 45 mm. stage. A large ganglion is invariably found near the sinuatrial node. The node is richly innervated from ganglia and nerve fibres present around it. In the heart of bat a few ganglionic cells are also found in the connective tissue within the sinuatrial node. A number of nerve fibres and a few ganglia were seen along side the atrioventricular node near the caudal part of the interatrial septum. In the heart of adult bat a few fine nerve fibres are seen intermingled with the fibres of the atrioventricular node. This node in pigeon and rabbit is devoid of any nerve element within. In bat and rabbit no nerve cell is present in relation to the atrioventricular bundle, however, in pigeon a few nerve cells are seen in relation to the atrioventricular bundle. Many nerve fibres are present within the atrioventricular bundle. Several nerves are seen running along side the atrioventricular bundle and its branches. After a short distance they leave the bundle to pass into the myocardium of the interatrial septum.

On the basis of the presence of multipolar, unipolar and bipolar ganglionic cells in the heart of these animals and as the cardiac ganglia are mainly concerned with the nerve supply either afferent or efferent to the cardiac muscles, it is suggested that the atria and the ventricles are innervated from both the sympathetic and the parasympathetic sources.

MYOGENIC VERSES NEUROGENIC

Regarding the myogenic and neurogenic theories of cardiac conduction facts have been presented on the morphological grounds, in favour of both these theories. It is put forth that the conduction system of the heart of these animals is formed of both the muscular and nervous elements. The nerves and ganglia are absent in the heart at early stages of development where it is the muscle fibre alone that forms the conducting system. It is suggested that from the time the nervous elements appear within the specialized structures, these structures function under the control of the nervous elements. The pathway for the conduction of the cardiac stimulus of contraction is formed of muscle fibres alone and nerves and ganglia control the activities of the specialized structures.

These conducting structures right from their primordial stage are histologically different from the other myocardial fibres. The conducting structures of the heart of birds and mammals are, therefore, not neomorphic in nature.

Evidences have presented in support of the view that the impulse initiating and conducting structures in birds and mammals are further specializations of the structures already present in the heart of lower vertebrates.

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UTILISATION OF HYBRID VIGOUR IN CASTOR *RICINUS COMMUNIS* LINN.*

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Castor oil is an important raw material for industry and is also exported for earning foreign exchange. The production of castor oil in our country is handicapped due to low yields of castor. The present study was taken up to utilise hybrid vigour for obtaining higher yields of castor seed. The following parents were used in the study because of their superior agronomic characters :— T3, T4, T9 and 4202 R/C from Uttar Pradesh, HC 6 from Andhra Pradesh, TMV 1 and 2 from Madras State, 4414 from Maharashtra, Cimarrom, US 74 and Baker from USA and RUS 1 and 2 from U.S.S.R.

1. During the course of the study observations were recorded on 16 morphological characters on 15 F1 hybrids. The hybrids displayed variations from the mean values for the parents in both the directions. A summary of the variations is given below:—

Charater	Number of hybrids showing value more than parental mean	Number of hybrids showing value less than parental mean
i. Height	9	6
ii. Number of nodes	6	8
iii. Diameter of stem	6	7
iv. Number of branches per plant	4	11
v. Number of leaves	2	13
vi. Diameter of leaves	11	4
vii. Days required for flowering	6	7
viii. Number of racemes per plant	5	9
ix. Total length of racemes per plant	4	11
x. Number of capsules per plant	7	8
xi. Length of main raceme	8	7
xii. Capsules per main raceme	9	6
xiii. Density of fruiting	11	4
xiv. Breadth of the seed	7	8
xv. Length of the seed	4	11
xvi. Weight of 100 seeds	8	7

N.B.—Where the value for the hybrid was exactly equal to the mean value for the parents, the hybrids have not been counted. Therefore the sum of figures in both the columns does not add up to 15 in all cases.

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2. Total correlations between estimated yield, observed yield and the morphological characters were worked out. Significant value for correlation coefficient was observed in respect of number of capsules per plant, total length of inflorescence per plant and the breadth of the seed.

The values for correlation coefficient between yield and (i) Number of racemes per plant, (ii) length of the main raceme (iii) weight of 100 seeds and (iv) number of capsules per main raceme were 0·30, 0·36, 0·29 and 0·36 respectively.

Correlation coefficients were also worked out on the basis of observed yield. The value for 'r' was significant in respect of total number of capsules per plant and total length of inflorescence per plant. A study of partial and multiple correlation coefficients revealed that number of capsules per plant was the only reliable character which was strongly correlated with yield. Density of fruiting as indicated by number of capsule per centimeter length of raceme and weight of 100 seeds did not turn out to be significantly correlated with yield.

3. Earlier study had shown that the height of the castor plants was not associated with yield. But the rate of increase in the height of the shoot and diameter of the leaf were found to be positively and significantly associated with yield.

4. Studies on floral biology revealed that opening of flowers, pollination and development of fruits proceeded normally in all the high combining lines, thus indicating that no bottlenecks existed in fruit set and development as far as floral biology was concerned.

5. Germplasm from different states in the country and exotic sources *viz.*, U.S.A., U.S.S.R., Nigeria, Australia and New Zealand was tested for production of hybrid castor seed.

The inbreds isolated from T3, T4, T9. 4414, 4202 R/C, HC6 and TMV 2 turned out to be good combiners and some of the hybrids gave very encouraging yields. T3×T4, TMV2×T3, TMV2×T4, T9×RUS 1/A-A, T9×5432, and T4×HC6 gave 4042, 4422, 4070, 4634, 4805 and 4819 Kg seed yield per hectare. The average yield of castor seed in India during 1961-62 was 224 Kg/ha.

6. Inbreds possessing strong pistillate tendency were isolated with a view to utilising them in commercial hybrid seed production. It was observed that some inbreds segregated in 3 : 1 ratio (monoecious : pistillate) indicating that the inheritance was monogenic. In others 9 : 7 ratio was observed indicating interaction of complimentary genes.

Seven pistillate inbreds *viz.*, 4414, RUS 1/A-B, EC 14811, CO-1, selections from RUS 1/A, HC 6 and HC 5 were tested for combining ability. The hybrid 14811×TMV 2 turned out to be the highest yielder producing 5125 Kg seed per hectare. The second best was RUS 1/A-A×T4 yielding 4157

Kg seed per hectare. The hybrids where Ec 14811 or RUS 1/A was one of the parents generally proved to be better yielders. The other promising hybrids were RUS 1/A-B×T4, Ec 14811×Cimarron, CO-1×T4 and HC5×5904.

7. The tests for combonog ability of inbreds and yielding ability of the hybrids revealed that high yielding hybrids can be produced from the inbred lines already available. In actual trials about half a dozen hybrids produced more than 4000 Lbs seed per acre which is twenty times the average yield of the country and about ten times the average yield of Uttar Pradesh.

8. Hybrid seed was produced by following natural crossing block method in which 7 monoecious lines were used as seed parents. The method was found to be suitable for commercial hybrid seed production for the present. Subsequently when male-sterile lines are available they could be used for the purpose.

9. Two lines have been isolated from EC 14811 and EC 13334 which fail to set fruit and produce seed when selfed. These are probably male sterile. This awaits confirmation and further studies.

10. Procedure to produce hybrid seed by using monoecious as well as pistillate lines has been given. The seed was produced under field conditions by using the recommended methods.

11. Pistillate plants were noticed in a number of F1 hybrids. Utilisation of such F1 hybrids for production of three way crosses has been discussed. Some hybrids where the frequency of occurrence was more than 20 per cent are RUS 1/A×5432 (22 per cent), 4414×T4 (26 per cent), 4202 R/C×RUS 1/A (33 per cent), RUS 1/A-A×T9 (37 per cent), RUS 1/A-A×EC 14811 (55 per cent) and HC6×HC5 (55 per cent). In a number of other hybrids pistillate plants were less than 20 per cent.

12. Oil content of the seed was determined with a view to evaluating them for their ability to produce castor oil. As oil is the most important product of castor plant it was thought proper to assess this aspect as well. The hybrids T4×Cimarron, HC6×T3, 4202 R/C×RUS 1/A, RUS 1/A×T9, T9×T3 and TMV2×T3 possessed higher oil content than either of the parent ; hybrids 4202 R/C×T3, T3×HC6, HC6×4414 and T3×US 74 had intermediate oil content while in HC6×RUS2, T3×T4 and 4413 A/A×T3 it was lower than either of the parents.

14. It has been suggested that the yield of oil per hectare should form the basis to evaluate either hybrids or superior lines. Total seed yield or oil content in the seed are not considered to be reliable to indicate the value of the seed.

In the present study RUS 1/A×4202 R/C had 53·6 per cent oil, while T4×Cimarron had 53·8 per cent, and HC6×T3 had 53·7 per cent. The hybrid RUS 1/A×4202 R/C was considered to be the most suitable as it produced 2725 Kg. oil per hectare. The others which had higher oil content in the seeds produced only 1804 and 2206 Kg/hec respectively.

14. Dehiscence of capsules and the shelling percentage were found to be associated. The varieties which show delayed dehiscence also have lower shelling per cent. The variety T4 which resists shattering in the field had 62·5 shelling percentage and T9 which resists shattering to a greater extent the shelling percentage was 61·6. Contrary to the above T3 has a tendency towards shattering in the field and its shelling percentage was observed to be 64·7. The variety Cimarron which shatters to a greater extent than T3 the shelling percentage was higher than that of T3. It was 70. In the hybrids figures for shelling percentage tended to be in between the values for parents, but in three hybrids where 4202 R/C was the pistillate parent the shelling percentage in the hybrid was higher than the shelling percentage of either of the parents. It has been suggested that the dehiscence of the capsules should be such that it may permit one picking or even mechanical picking. If the fruits have a tendency for delayed dehiscence both these objectives are fulfilled. Side by side the shelling percentage should also be high.

15. Dwarf internode hybrids—US 74 a dwarf variety was tested with parents having normal internode length such as T3 and T4. The hybrids which were of intermediate height were not inferior to T3 or T4 in yield. This aspect needs further investigation since from the above studies no conclusions can be drawn.

16. Observations were recorded on the reduction of yield in F2. Seven hybrids *viz.*, RUS 1/A×T4, TMV1×T3, Cimarron×T4, RUS 1/A-B ×T9, RUS 1/A-III×4202 R/C, HC6×4202 R/C and HC6×T4. The F1 and F2 generations were grown side by side in an observational trial which was not replicated. The reduction in yield was found to vary between 11 to 82 per cent.

17. The effect of pollen was noticed on size and the colour of the seeds formed after pollination. The seeds varied in size when different pollens were used on different racemes even on the same plant. Seed colour also varied with the type of the pollen used.

18. In the crosses involving parents with spiny and spineless fruits the capsules of the hybrids displayed intermediate spinyness.

19. Crosses involving early and delayed dehiscing parents the hybrids generally had intermediate dehiscence.

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STUDIES ON THE OCCURRENCE OF LEPTOSPIRAL INFECTIONS IN DOMESTIC ANIMALS AND RODENTS*

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The present study has been undertaken to determine the extent of leptospiral infection in Northern India particularly Mathura, Agra region by means of cultural, serological and histopathological studies of the domestic animals and rodents of the area.

Materials from 137 kidneys and 5 livers from rats, 7 kidneys and 7 livers from jaundiced buffalo carcasses and 1 kidney and 1 liver from a dead goat of a suspected flock were processed in different media. Isolation techniques were followed on the lines advocated by World Health Organisation Bulletin (1956). Four liquid and 2 semisolid media were employed namely, modified Vervoort's medium, Korthof's medium, Stauarts medium, Fletcher's broth medium, Fletcher's agar medium and Dingers modification of Noguchi's medium. Mostly pooled rabbit serum was used for the enrichment of the medium, but horse and sheep sera were also used when rabbit serum was not available. The culture tubes were incubated at 37°C for 4 to 5 days and later at room temperature ranging from 25-30°C. From the fourth day onwards these cultures were examined periodically at interval of 3 to 5 days upto 30 days, after staining with either Giemsa method or Hage-Fontana method. Cultures were also examined under phase contrast microscope whenever necessary.

Young guinea pigs were used for propagation and isolation of the organisms from contaminated cultures and 27 suspected urine samples from a flock of sheep and goats in which a few abortions had earlier been observed. Suspected materials were inoculated intraperitoneally and observations for 3 weeks were carried out for the symptoms such as trise ofemperature, loss of appetite, loss of weight and jaundice. Guinea pigs were also used as live filter system for the purification of suspected and contaminated cultures.

A total number of 1779 sera samples were screened for the presence of leptospiral antibodies, which include 285 sera samples from buffaloes, 8 from horses, 6 from donkeys, 595 from goats, 493 from sheep, 57 from pigs, 193 from dogs, 137 from rats and 5 from ducks. Macroscopic plate agglutination tests were carried out on these sera samples against 5 Leptospira pool antigens imported from Difco Laboratories Detroit, Michigan, U. S. A. These pool antigens were containing the following individual antigens.

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Pool 1: *L. ballum*, *L. caincola*, *L. icterohaemorrhagiae.*
Pool 2: *L. bataviae*, *L. grippotyphosa*, *L. pyrogenes.*
Pool 3: *L. autumnalis*, *L. pomona*, *L. sejroe.*
Pool 4: *L. australis*, *L. hyos*, *L. minigeorgia* (LT 117).
L. Kremastos pool: *L. kremastos* and *L. biflexa.*

A few control antisera were also imported for the comparison of the test.

Histopathological studies were carried out on the kidneys of 5 buffaloes, 1 goat, 4 dogs, 10 rats and livers of 2 buffaloes and 1 goat. Dobell's modification of Levaditis silver impregnation method of staining was done for staining the tissue materials.

Attempts for cultural isolation gave negative results and not a single strain of Leptospira could be isolated. Isolation attempts through guinea pigs passage of the contaminated cultures and suspected urine samples also did not reveal any positive result. Similarly histopathological studies conducted on the tissue materials failed to demonstrate Leptospira in tissue sections.

Sera samples were examined for the presence of leptospiral antibodies turned to be negative. A few doubtful sera samples from rats which were forwarded to Leptospiraspirosis Reference Laboratory, London, were reported to be negative even at a titre of 1/5.

The various implications in the spread of the disease have been discussed alongwith the reported regional and seasonal variations.

STUDIES ON THE OCCURRENCE OF SALMONELLAE FROM VARIOUS SOURCES*

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An investigation was undertaken to find out the occurrence of common as well as rare Salmonella sero-types from various sources and to study its epidemiological and public health importance.

Faecal samples of 113 apparently healthy men, 308 pigs, 20 fowls, 50 pigeons, 25 ducks, 47 dogs, 41 camels and 29 rabbits alongwith 171 sewage, 5 bone and 4 fish meal samples, were screened for the presence of salmonellae. Besides these, heart blood and internal organs of 208 dead chickens and 14 dead rabbits were examined for evidence of infection.

The combinations of Kauffmann's modified tetrathionate broth as enrichment, brilliant green agar as selective and modified MacConkey agar as purifying and differential media were used throughout the study except for few odd samples for which salenite broth and desoxycholate citrate agar and Salmonella Shigella agar were employed. The isolated cultures were preliminarily identified by Poly valent "A-53" O sera and Salmonella genus specific "O-I" phage and confirmed by biochemical tests. Both "O" and "H" antigenic structures were studied and the results were confirmed by Dr. Joan Taylor of Salmonella Reference Laboratory, London. Poly Valent 'A-E' sera was prepared for laboratory use.

Out of 1035 specimens examined, 96 salmonella strains, comprising 20 serological types including a new one, *Salmonella gokul,* were isolated from the various sources. The frequency and distribution of the serotypes are as follows: *S. anatum* (6) from pigs, pigeons and rabbits; *S. bareilly* (5) from fowls, sewage and bone meal; *S. gaminara* (1) from sewage; *S. give* (2) from man; *S. hessarek* (7) from dead and healthy rabbits; *S. lansing* (1) from sewage; *S. london* (1) from sewage; *S. newport* (14) from pigs; *S. oritamerin* (2) from sewage; *S. paratyphi B* (1) from sewage; *S. poona* (1) from pig; *S. saintpaul* (1) from sewage; *S. senftenberg* (5) from pigs, ducks and bone meal; *S. stanley* (10) from pigs, dead chicken and pigeons; *S. tel-hashomer* (1) from man; *S. typhimurium* (4) from pigs, dead chicken, dead rabbits and sewage; *S. weltevreden* (27) from man, pigs, dead chicks and sewage; *S. richmond* (5) from pigs and sewage; *S. tennessee* (1) from bone meal and new type *Salmonella gokul* (1) from pigs.

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* This is an abstract of the thesis submitted in partial fulfilment of the requirements for the degree of M.V.Sc. in Bacteriology of the Agra University (1963).

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S. gaminara, *S. give*, *S. hessarek*, *S. lansing* and *S. oritamerin* are recorded for the first time in India. The new species named as *Salmonella gokul* was recovered from an apparently healthy pig. Its antigenic structure is 1,51:d:— and has been placed in subgenus I on biochemical behaviour.

The phage typing of isolated strains of *Salmonella typhimurium* revealed, 2 belonging to phage type Ia, 1 to phage type II and 1 was untypable. Both phage types *i.e.*, Ia and II are reported for the first time in the country.

The various implications of these findings from epidemiological and public health point of view are discussed and the necessity of carrying out further work particularly on the new serotype, *S. gokul* is stressed.

STUDIES ON THE PITUITARY GLAND IN *BARBUS TOR* (*TOR TOR*)*

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For the present study of the gonads and pituitary gland, *Barbus tor* was chosen. This fish is one of the major carps of Indian fresh-waters. It belongs to family Cyprinidae, order Cypriniformes. The specimens were collected from Bhimtal lake situated in the Himalayas at a height of 4500 feet above sea level.

The pituitary glands were fixed in mercuric formaldehyde and Bouin's fluid which gave the best results. Staining was done with Dawson and Friedgood, periodic acid-Schiff, aldehyde fuchsin and chrome alum haematoxylin techniques.

The gonads were fixed in various fixatives, but the best results were obtained by Bouin's fluid. The stains employed were Heidenhain iron haematoxylin (long method), Ehrlich's, Delafield's and Harris' haematoxylin. Eosin and orange G were used as counter stains. Azan technique has also been utilised for ovaries. Chemical nature of yolk vesicle was tested with periodic acid-Schiff (PAS) technique.

The pituitary gland, which lies in the myodome, is a long ovoid structure situated on the ventral side of the brain attached to the infundibulum by means of a short stalk, which enters the gland from its posterior side (caudolepto-basic type). The gland is oriented in such a manner that its anterior end lies posteriorly and posterior end anteriorly.

Histologically, four regions are distinguished in the pituitary gland: (i) Neurohypophysis, consisting of nerve fibres and neuroglia cells; the neurosecretory fibres and materials are seen in close association with blood capillaries and parenchyma cells of the pars intermedia (meta-adenohypophysis) suggesting some physiological relationship between them (ii) Rostral pars distalis (pro-adenohypophysis, lying dorsal to the mesoadenohypophysis in the form of a thin stripe, consists of mostly acidophils which are PAS and AF negative (iii) Proximal pars distalis (meso-adenohypophysis) lying almost in between rostral pars distalis and pars intermedia consists of all the three cell types, *viz.*, acidophils, basophils and chromophobes. The basophils are the dominating cell types which are both PAS and AF positive. They are also stained with chrome alum/haematoxylin. (iv) Pars intermedia lying at the distal tapering end of the pituitary gland, consists of dull acidophils, basophils and chromophobes which are PAS and

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* Abstract of the Thesis submitted for the degree of Doctor of Philosophy of the Agra University, Agra, in 1963.

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AF negative but the acidophils and basophils are stained with phloxine of chrome alum/haematoxylin. Pars intermedia is richly ramified by the neurohypophysial branches.

The testes are a paired structure lying in the abdominal cavity and open externally by a common aperture. Histologically, two regions are distinguished: the main body which is functional, and the posterior body which is sterile. All the stages of spermatogenesis have been recorded.

The testicular cycle is divisible into four stages, *viz.*, (i) Growth (November to March), (ii) Maturation (March to April), (iii) Activation (April to August) and (iv) Depletion (September to October). The spermatogenetic activity starts in the month of November and continues upto the end of March when the testes are full of spermatids and sperm. From April onwards spermatogenesis is slowed down. It is reduced considerably by September, and comes to an end by October. This testicular cycle is in conformity with the gonosomatic index of the fish.

The ovaries are a paired structure, lying in the abdominal cavity and open externally by a common aperture. They show profound changes, both morphological as well as histological. Nine stages of the developing oocytes have been recognised. They are : (i) chromatin nucleolus stage, (ii) perinucleolus stage, (iii) yolk vesicle stage, (iv) primary yolk stage, (v) secondary yolk stage, (vi) tertiary yolk stage, (vii) migratory nucleus stage, (viii) pre-ripening stage, and (ix) ripe egg stage.

Yolk formation has been studied, and it is observed that yolk globules first appear on the periphery in the extra vesicular cytoplasm and later invade the cytoplasm around the nucleu. Yolk nucleus has been observed to arise in the cytoplasm near the nuclear membrane, and it migrates later towards the periphery. Lamp-brush chromosomes have been seen at the perinucleolus stage of oocytes.

In the ovarian cycle six stages have been recognised, *viz.*, (i) Immature virgin (all the year round), (ii) Developing virgin (January to April) or reviving spent (November to March), (iii) Maturing (March to July), (iv) Pre-spawning (April to September), (v) Spawning (April to September), and (iv) Spent (August to October).

Atretic eggs are present throughout the year, but they are most common in the spent ovary. The so-called pre- and post-ovulation corpora lutea have been described.

Here the same ovary contains enormous number of oocytes at various stages of development during the breeding period, and there is a continuous conversion of younger oocytes into subsequent developing and maturing stages. The fish thus has a long spawning period extending from April to September and spawns several times during a single spawning season. The ovarian cycle exhibited by the fish is in conformity with the gonosomatic index and ova-diameter.

It has been established that in relation with the seasonal changes in the gonads, the basophils of the proximal pars distalis undergo parallel changes of granulation, degranulation and vacuolization. This periodicity in the behaviour of the basophils is due to the degree of concentration of the glycoprotein contents in their cytoplasm. This activity of the pituitary gland has been described into three phases, *viz.*, (i) phase of involution and inactivity (September to October), (ii) phase of restitution (November to March) and (iii) phase of storage and discharge (March to August).

In the male the testis attains its full maturity in the month of March, after which it is depleted, and starts growing again from the month of November. This testicular cycle is in conformity with the values of the gonosomatic index of the fish. If basophilic cell area is taken as a criterion of pituitary activity, it is seen that its values are favourably related to those of the gonosomatic index of the fish. The highest value of the basophilic area and that of the gonosomatic index is reached in the months of March-April.

In the female the maturing stage of the ovary starts from March and extends upto July. It is from the months of April that spawning begins and continues till September. This is followed by a spent and developing period of the ovaries. This ovarian cycle is in conformity with the gonosomatic index of the fish. The values of the basophilic cell areas in the female fish are highest in the months of March-April, while those of the ova-diameter and gonosomatic index are highest in the months of May-June. This difference is due to an earlier activation of the pituitary gland. The month of March is the maturing period, and it is from April that spawning begins. Thus the relative values of the basophilic cell-areas and ova-diameter are in conformity with the reproductive cycle of the female fish.

If the values of basophilic cell areas are seen in the pituitary of the male and female fish they coincide very well, indicating similar periodicity in the activity of the pituitary in both sexes. The highest value is reached in March-April in both, while it is lowest in November-December. However, the values of the gonosomatic index in the male and female fish show some variation. In male the highest value is reached in March-April, while in female in May-June. This can be explained on the basis that in males the testes become fully ripe by March-April, while in females the maturing process continues alongside spawning till a late period.

The activity of PAS and AF positive cells near the border of proximal pars distalis and pars intermedia is remarkable. These cells, though deeply reactive to PAS and AF, are relatively less degranulated and vacuolized than those in the proximal pars distalis proper. Some of them even may not show any sign of degranulation and vacuolization. These cells are more or less oval and round in shape, and possess nuclei of the same shape placed eccentrically. Their appearance suggests a lower activity than that of those cells undergoing active degranulation and vacuolization during spawning

ON ONCHOCERCAL LESIONS IN AORTA OF INDIAN DONKEY - (*EQUUS ASINUS*)*.

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During a search for helminthic infections in the aorta of twenty-eight donkeys, *Equus asinus*, autopsied during the teaching session 1962-63, three aortae revealed lesions which, on teasing, revealed inside characteristic tortuous galleries adult specimens of the filarioid nematode, *Onchocerca armilata* Railliet and Henry, 1909 which, as far as could be ascertained, does not seem to have yet been reported from equines in any country of the world. Its incidence, however, is known in our bovines and ovines (Bhatia and Sood, 1959, Bhatia, 1960) and pig (Ramanujachari and Alwar, 1954). The lesions, after histological study, are herein described.

The Morphology of *O. armillata* has recently been described by Chodnik (1957) who has also given an account of its histopathology in infections of cattle (1958). Patnaik (1962) has also dealt with infections in cattle in Orissa. Its present finding in donkey enlarges the range of its known hosts.

The parasites, as described by Chodnik, occurred at the sites of the lesions. In their morphology, from a study of fragments of both males and females recovered from the lesions, no structural differences were found from the account given by Chodnik. Fragment of a female worm, in its posterior region, revealed, however, that the cuticular striations in this terminal part were much less pronounced than in the regions anterior to it and the anus was nearly terminal in position.

The gross lesions, on the intimal lining of the aorta, consisted of prominent corrugations over the wavy tunnels—the abode of the parasite (Fig. 1). In case of the tunnels, free from the parasite, the affected regions were considerably thickened and grossly corrugated. A distinct nodule formation was not observed. Chodnik, on the other hand, found occasionally well-defined nodules even of a larger size. Some of the lesions, on their outer surface, revealed a darker colouration while others were with a lighter consistency.

The histological study of a large number of lesions, in tissue fixed in 10% Formaline, from the series of stained sections, (H. & E.) showed both male and female worms cut in different regions revealing characteristically the features of the morphology of their body wall, digestive and reproductive systems. The oesophageal region was cut in some sections, the anterior end and posterior part of a male with the characteristic spicule was visible in others.

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* Part of the Thesis approved for the award of M.V.Sc. degree of Agra University (1963) to J. C. K. under the supervision of B.P.P.

In some sections, with the female cut, the ovary and the uterus with thick rigid walls containing eggs were seen and in some others the intestine and uterus filled with microfilarae were present. The lesions, with a darker consistency of its surface, were found to harbour male worms in the media and those of a lighter character had the gravid female towards the the intima. In another series of a female, cut in a deeper situation in the intima, the worm appeared to have died as the surrounding area revealed calcification (Fig. 2). In darker lesions, associated with male worms, an extensive haemorrhage was observed while in case of those with females a milder degree of congestion was apparent.

The male worms, embedded in the media, had broken the continuity of the endothelial lining at various places. Areas of extensive haemorrhage (Fig. 3), in the vicinity of the parasite and at other places probably left by it, revealed a large number of macrophages which seemed to have invaded or phagocytised the dead and degenerating red blood-cells. A characteristic feature, invariably noticed in the sections before and after staining, consisted of a greenish and yellowish pigment in the cytoplasm of these cells (Fig. 4). Similar pigment was also noticed in the intercellular spaces in close vicinity of the parasite (Fig. 5). In medial and adventitial coats extravasated blood in the intercellular spaces besides focal areas of mononuclear infiltration with lymphocytes, macrophages (Fig. 6) and few of the eosinophils were evident in close vicinity of the parasite. Haemorrhagic areas also occurred at the junction of the intimal and medial coats and the adjacent tissue revealed a degree of hyperplastic changes along with the pigment—changes suggestive of granular tissue. In other sections, an encapsulation (Fig. 7) from a zone of proliferating fibroblasts and collagenous fibres was observed. In the media, a mild degree of eosinophilic infiltration in the vicinity of the parasitic zone was in evidence (Fig. 8).

In case of some of the embedded males, the inflammatory changes appeared to have virtually stopped at the cellular stage, as there was either no fibrosis or only a moderate degree of fibrosis. In sections of the tunnels, free from parasites, extravasated blood was present and some of these tunnels had even collapsed with a varying degree of obliteration. In some others, the lumen was partly occluded and narrow tract of granulation tissue were reveald.

The tunnels, harbouring the females, were mostly in the intimal layer just beneath the endothelium (Fig. 9) where the degree of pathological changes were not profound. A diffuse type of haemorrhage, characterised by the presence of a number of red-blood cells distributed beneath the lining and a congestion of vasa vasorum was noticed in the stained sections. A thin capsule from fibroblastic and collagenous fibres surrounded the worm. In case of the females, lying more superficially than males, the various foci were confined to the endothelium alone. No reactionary cells generally occurred around the worm but, at some places, a few focal areas of mononuclear infiltration in the intimal zone were present, the predominent cells being lymphocytes with a few macrophages. Few of the eosinophils were also noticed at places. The characteristic pigment, noticed in the vicinity of male worms, was absent.

SUMMARY

Examinations of twenty-eight specimens of *Equus asinus* and thirteen of *Equus caballus*, after autopsy, revealed infections with *Onchocerca armillata* in the former alone. The lesions were studied grossly and microscopically. *O. armillata*, in donkey, is a first report in equines. Pathological changes around the harboured stages have been described in some detail.

ACKNOWLEDGEMENT

Thanks are due to the Principal of the College for facilities provided.

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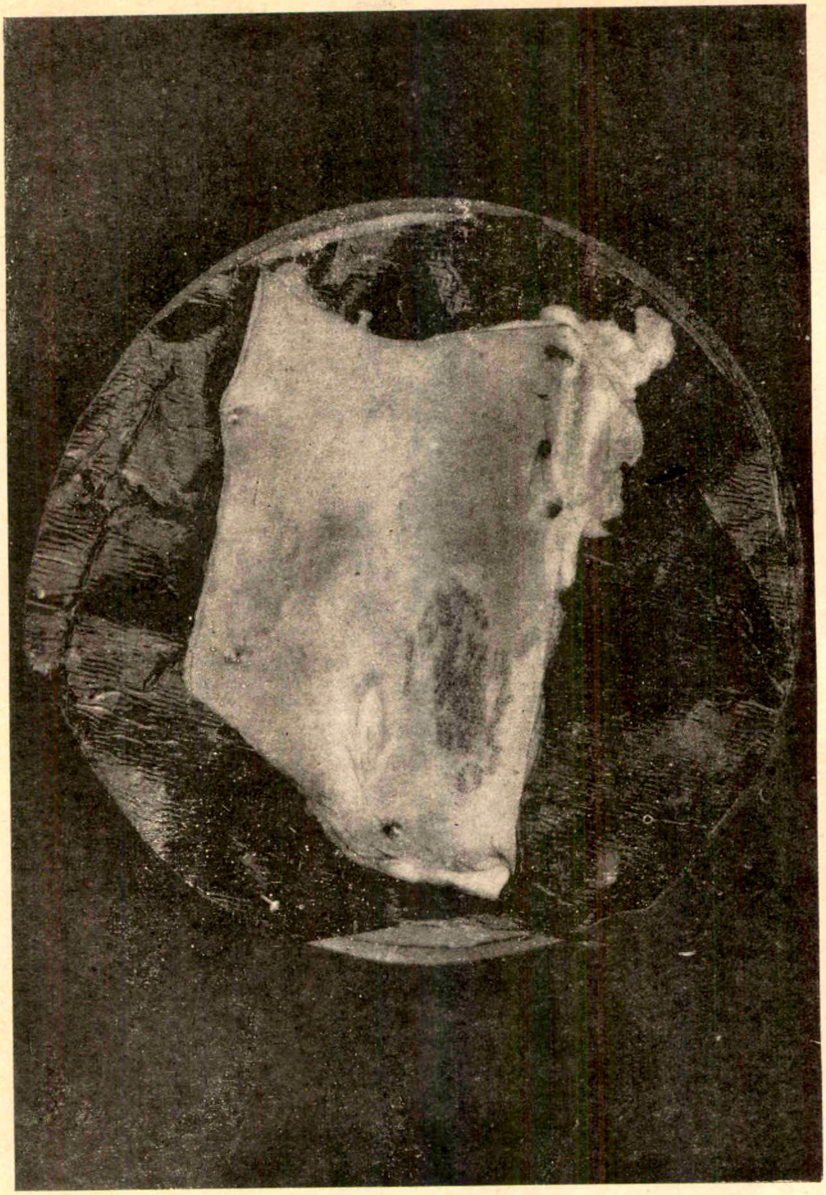

Fig. 1. Photograph of a portion of aorta showing characteristic lesion.

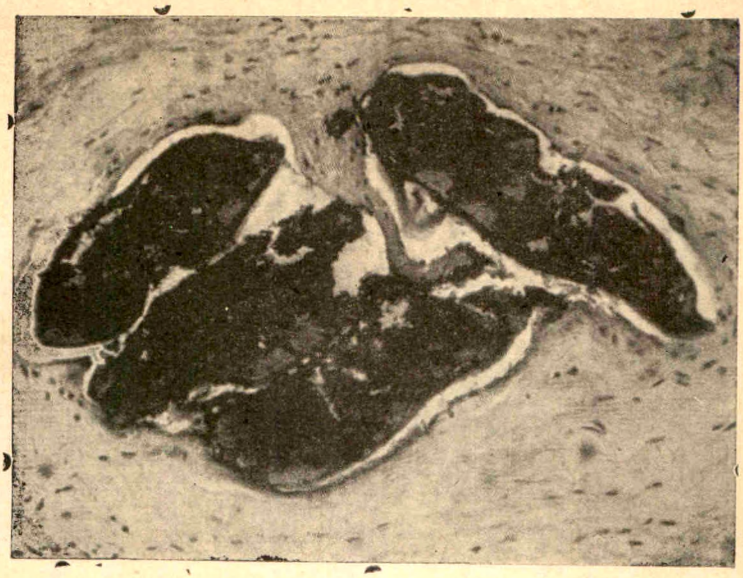

Fig. 2 to 9, Photomicrographs of sections of aorta.

Fig. 2. A portion of section, showing calcified female. X 170.

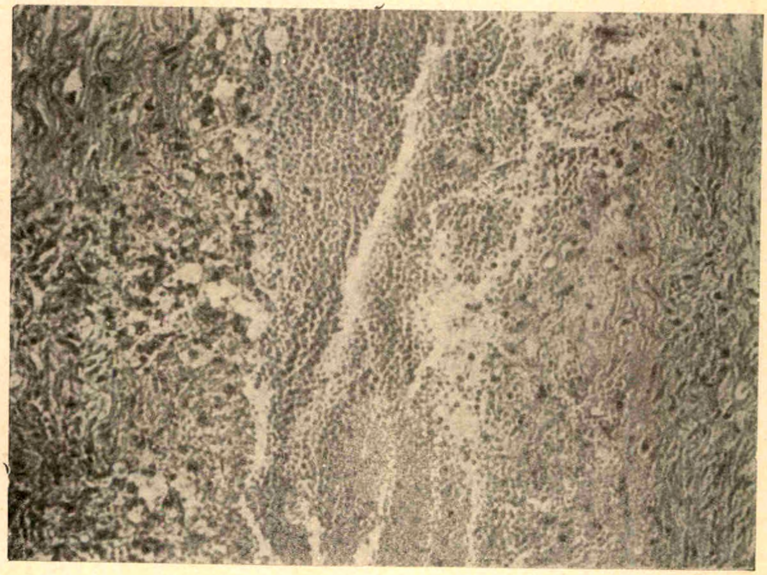

Fig. 3. A portion of another section, showing extensive haemorrhage. X 190.

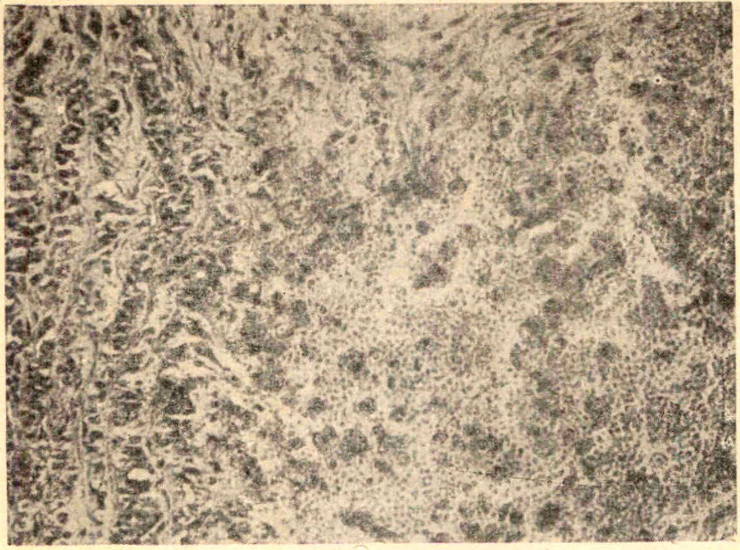

Fig 4. A portion of another section showing haemorrhage and macrophages. X 190.

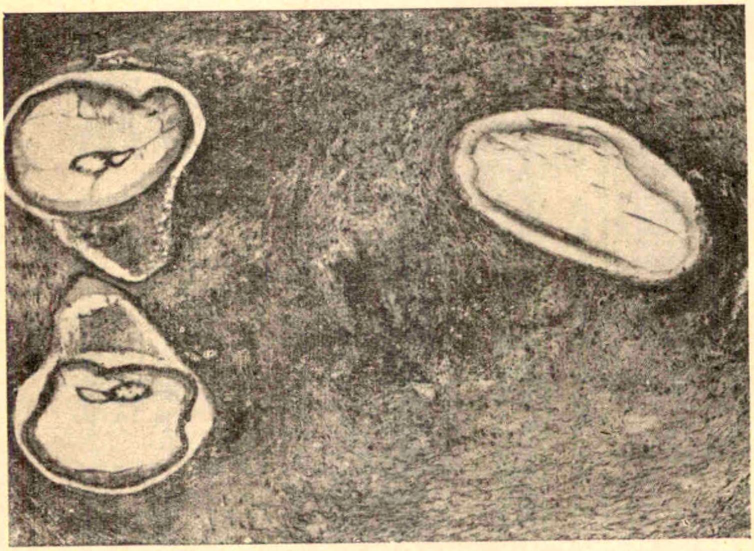

Fig. 5. A portion of another section, showing yellow pigment around the male worm. X 90.

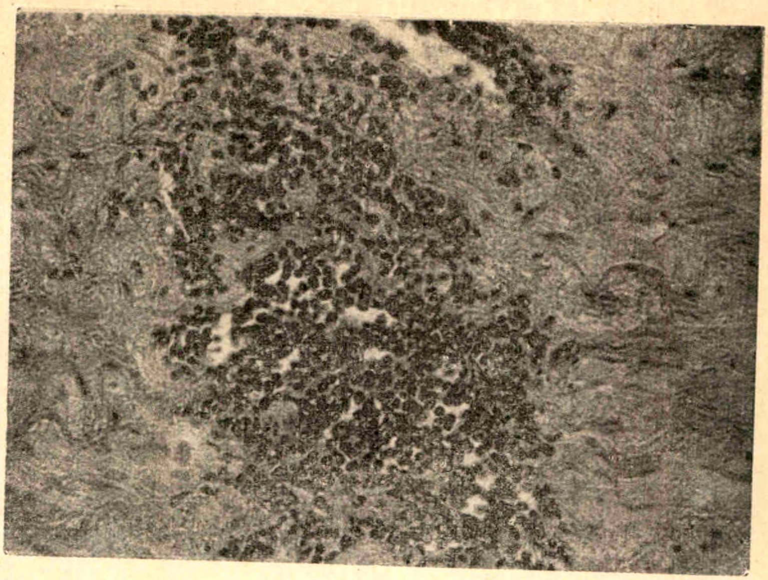

Fig. 6. A portion of another section, showing lymphocytic infiltration around male worm. X 300.

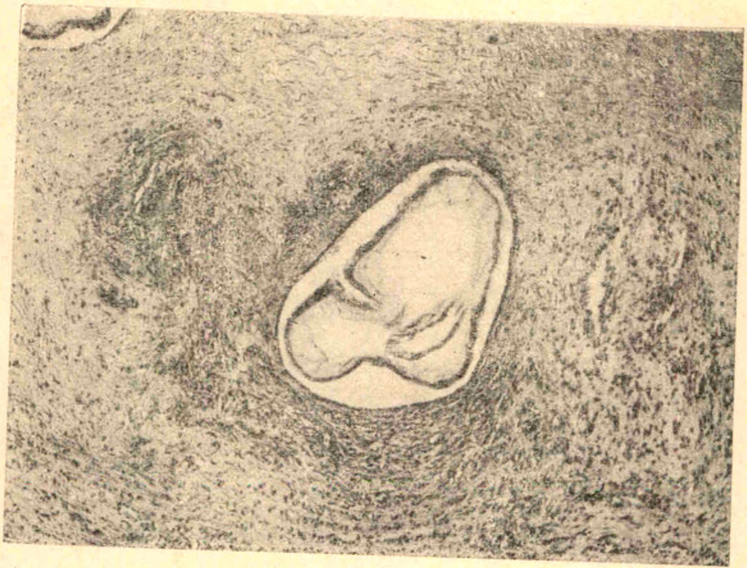

Fig. 7. A portion of another section, showing encapsulation around male worm. X 90.

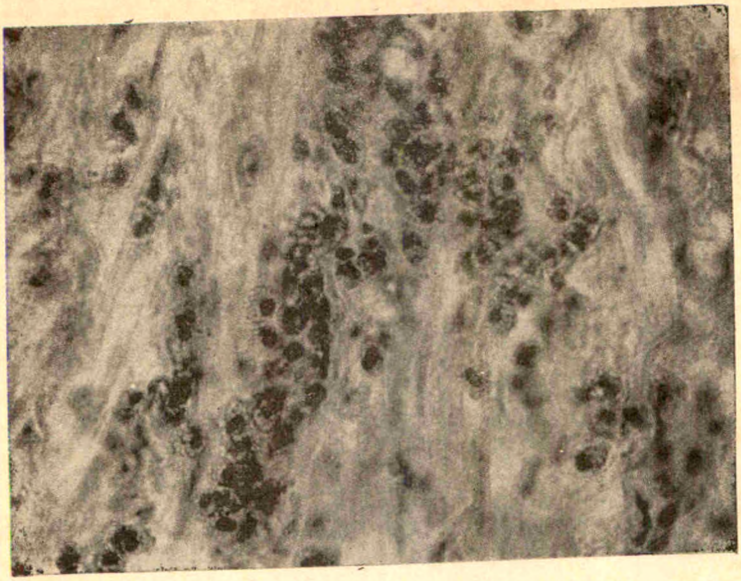

Fig. 8. A portion of another section, showing eosinophilic infiltration around male worm. X 550.

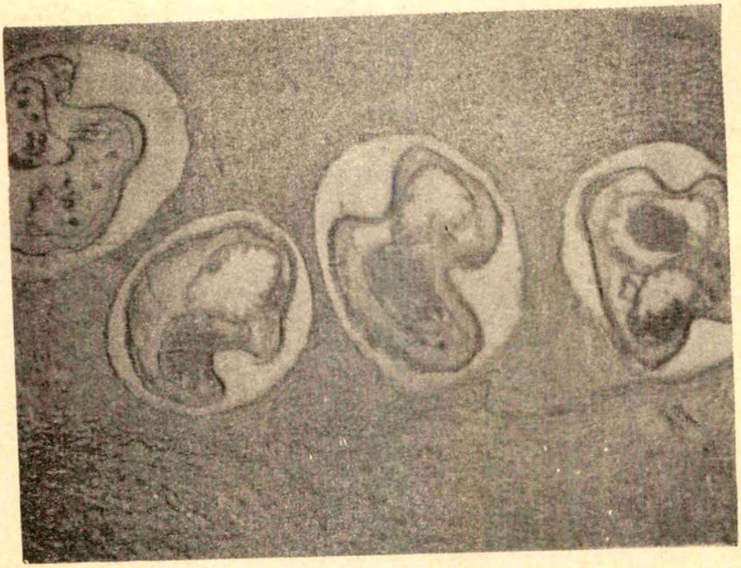

Fig. 9. A portion of another section, showing female worm cut just beneath endothelium. X 170.

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CHANGES ON ACCOUNT OF SMALL STEADY DISTURBANCES IN A COMPRESSIBLE FLOW

HAR SWARUP SHARMA
Agra College, Agra.

INTRODUCTION

Ray[1] discussed the variation of temperature due to small steady disturbances in a slightly compressible fluid. The effects of viscosity were taken into account and the condition was taken as non-adiabatic. Usual method of neglecting squares and products of the components of disturbed velocity was adopted. He found that (1) the variation of temperature is proportionate to that of velocity and (2) the disturbance depends only on one parameter that is Prandtl number σ. For the solution of the equations he assumed

$$\frac{\partial\psi}{\partial x}=au,\ \frac{\partial\psi}{\partial y}=bu$$

where u is the change in the disturbed velocity and a, b are constants. But actually $\frac{\partial\psi}{\partial x}$ and $\frac{\partial\psi}{\partial y}$ both are functions of u.

In a recent paper the same results were obtained by the present writer after assuming

$$\frac{\partial\psi}{\partial x}=a\,f(u),\ \frac{\partial\psi}{\partial y}=b\,f(u)$$

However he was not able to find the values of a and b separately, as Ray[1] did in his case. But the purpose was served by a relation which existed between a and b and the value of $\frac{b}{a}$, which was needed was obtained in parameter σ.

In the present paper we have discussed the same problem by assuming

$$\frac{\partial\psi}{\partial x}=f(u),\ \frac{\partial\psi}{\partial y}=F(u)$$

In this case also the same results have been obtained. The value of λ was found by Ray and the present author in his previous paper, given by

$$\lambda=\sqrt{\left\{\frac{3\,(1-\sigma)}{4\,\sigma-3}\right\}}$$

But in this case λ has been found as

$$\lambda=\sqrt{\left\{\frac{2\,(1-\sigma)}{4\,\sigma-3}\right\}}$$

This difference does not affect the results of the problem as in both the cases λ depends on the parameter σ. Moreover it has also been found that

$$f(u)=a+3\rho_0\,U\,(1-\sigma)\,u$$

and
$$F(u)=A f^{\frac{2}{3}}(u)$$
where
$$A^2=\frac{9}{8}\,\frac{4\sigma-3}{1-\sigma}\,a^{\frac{2}{3}}.$$

The constant a could not be determined as the equations are not sufficient to determine all the constants. However a relation has been obtained to eliminate a and the purpose has been served.

DISTURBANCE EQUATIONS

Let the direction of the undisturbed stream be taken as x-axis and the flow be supposed to be non-adiabatic and two dimensional. If the disturbance is small and the fluid is very slightly compressible, then the variation of velocity, temperature, and pressure will be very small. Let U be the velocity of the fluid. Assuming the disturbance only in the x-direction let $U+u$ be the disturbed velocity. If ρ_0 be the density in the undisturbed state and let $(\rho_0+\rho)$ be the density when disturbed. The quantities u, ρ are small so that their squares and products and their first partial derivatives can be neglected.

Let pressure be constant.

The equation of continuity is
$$\frac{\partial}{\partial x}\{(\rho_0+\rho)\ (U+u)\}+\frac{\partial}{\partial y}\{(\rho_0+\rho)\ v\}=0,$$
which simplifies into, with the above assumptions
$$\rho_0\frac{\partial u}{\partial x}+U\frac{\partial \rho}{\partial x}=0 \qquad ..(1)$$
The equations of motion are
$$(\rho_0+\rho)\left\{(U+u)\ \frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right\}=\frac{\partial}{\partial x}p_{xx}+\frac{\partial}{\partial y}\ p_{xy},$$
and
$$(\rho_0+\rho)\left\{(U+u)\ \frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right\}=\frac{\partial}{\partial x}p_{xy}+\frac{\partial}{\partial y}\ p_{yy},$$
where
$$p_{xx}=2\mu\frac{\partial u}{\partial x}-\frac{2}{3}\mu\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right),$$
$$p_{xy}=\mu\left(\frac{\partial v}{\partial y}+\frac{\partial v}{\partial x}\right),$$
and
$$p_{yy}=2\mu\frac{\partial v}{\partial y}-\frac{2}{3}\mu\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)$$
With the above approximations, these equations simplify into
$$\rho_0 U\frac{\partial u}{\partial x}=\frac{4}{3}\cdot\frac{\partial}{\partial x}\left(\mu\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right) \qquad ..(2)$$

and

$$0=\frac{\partial}{\partial x}\left(\mu\frac{\partial u}{\partial y}\right)-\frac{2}{3}\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial x}\right) \qquad ..(3)$$

ENERGY EQUATION

If I be the enthalpy or heat content per unit mass in the undisturbed stream and $I+i$ be the enthalpy in the disturbed state, the equation of energy is

$$(\rho_0+\rho)\left\{(U+u)\frac{\partial i}{\partial x}+v\frac{\partial i}{\partial y}\right\}=\frac{\partial}{\partial x}\left(\frac{\mu}{\sigma}\frac{\partial i}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{\mu}{\sigma}\frac{\partial i}{\partial y}\right)$$

where $\sigma=\mu C_{p/k}$ is the Prandtl number, assumed constant, k the thermal conductivity and C_p the specific heat at constant pressure, assumed constant. It can be noticed that on the right hand side of the energy equation the dissipation function has been neglected in the present approximation as it consists of terms which are squares and products of partial derivatives so that no heat is generated by dissipation for such a small disturbance. Let i and its partial derivatives be small.

With these approximations the energy equation is reduced to

$$\sigma\rho_0 U\frac{\partial i}{\partial x}=\frac{\partial}{\partial x}\left(\mu\frac{\partial i}{\partial x}\right)+\frac{\partial}{\partial y}\left(\mu\frac{\partial i}{\partial y}\right) \qquad ..(4)$$

Now for a perfect gas we have

$$i\rho=\frac{\gamma p}{\gamma-1}$$

where $\gamma=\frac{C_p}{Cv}$, Cv being the specific heat at constant volume. Since p is constant, this law in the present case gives

$$(I+i)(\rho_0+\rho)=\text{Constant}=I\rho_0$$

or neglecting $i\rho$, we get

$$\rho_0 i+\rho I=0$$

$$\rho_0\frac{\partial i}{\partial x}+I\frac{\partial\rho}{\partial x}=0 \qquad ..(5)$$

Hence from (1) and (5) we get

$$U\frac{\partial i}{\partial x}=I\frac{\partial u}{\partial x}.$$

Since we have assumed that i is a function of u only, this gives

$$U\frac{di}{du}=I$$

Integrating

$$Ui=Iu \qquad ..(6)$$

taking $i=0$ when $u=0$.
Equation (6) then gives

$$\frac{d^2i}{du^2}=0 \qquad ..(7)$$

SIMPLIFICATION OF EQUATIONS

The equation (3) is satisfied if we put

$$\mu\frac{\partial u}{\partial x}=\frac{\partial\psi}{\partial x} \text{ and } \mu\frac{\partial u}{\partial y}=\frac{2}{3}\frac{\partial\psi}{\partial y} \qquad ..(8)$$

Then the equation (2) gives

$$\rho_0 U\frac{\partial u}{\partial x}=\frac{4}{3}\frac{\partial}{\partial x}\left(\frac{\partial\psi}{\partial x}\right)+\frac{2}{3}\frac{\partial}{\partial y}\left(\frac{\partial\psi}{\partial y}\right) \qquad ..(9)$$

Since i is the function of u alone, the energy equation (4) gives

$$\sigma\rho_0 U\frac{\partial i}{\partial u}\frac{\partial u}{\partial x}=\frac{\partial u}{\partial x}\frac{\partial}{\partial u}\left(\mu\frac{di}{du}\frac{\partial u}{\partial x}\right)+\frac{\partial u}{\partial y}\frac{\partial}{\partial u}\left(\mu\frac{di}{du}\frac{\partial u}{\partial y}\right)$$

and therefore from (8) we get

$$\sigma\rho_0 U\frac{\partial\psi}{\partial x}\frac{di}{du}=\frac{\partial\psi}{\partial x}\frac{\partial}{\partial u}\left(\frac{\partial\psi}{\partial x}\frac{di}{du}\right)+\frac{4}{9}\frac{\partial\psi}{\partial y}\frac{\partial}{\partial u}\left(\frac{\partial\psi}{\partial y}\frac{di}{du}\right) \qquad ..(10)$$

To solve these equations we further assume that

$$\frac{\partial\psi}{\partial x} \text{ and } \frac{\partial\psi}{\partial y}$$

are functions of u alone.

Then equation (9) becomes

$$\rho_0 U\frac{\partial u}{\partial x}=\frac{4}{3}\frac{\partial u}{\partial x}\frac{d}{du}\left(\frac{\partial\psi}{\partial x}\right)+\frac{2}{3}\frac{\partial u}{\partial y}\frac{d}{du}\left(\frac{\partial\psi}{\partial y}\right)$$

From (8) it becomes

$$\begin{aligned}\rho_0 U\frac{\partial\psi}{\partial x}&=\frac{4}{3}\frac{\partial\psi}{\partial x}\frac{d}{du}\left(\frac{\partial\psi}{\partial x}\right)+\frac{4}{9}\frac{\partial\psi}{\partial y}\frac{d}{du}\left(\frac{\partial\psi}{\partial y}\right)\\&=\frac{2}{3}\frac{d}{du}\left(\frac{\partial\psi}{\partial x}\right)^2+\frac{2}{9}\frac{d}{du}\left(\frac{\partial\psi}{\partial y}\right)^2\\&=\frac{2}{9}\frac{d}{du}\left\{3\left(\frac{\partial\psi}{\partial x}\right)^2+\left(\frac{\partial\psi}{\partial y}\right)^2\right\}\end{aligned}$$

Therefore

$$\frac{d}{du}\left\{3\left(\frac{\partial\psi}{\partial x}\right)^2+\left(\frac{\partial\psi}{\partial y}\right)^2\right\}=\frac{9}{2}\rho_0 U\frac{\partial\psi}{\partial x} \qquad ..(11)$$

SOLUTION

Now to solve (10) and (11) let us assume

$$\frac{\partial\psi}{\partial x}=f,\ \frac{\partial\psi}{\partial y}=F \qquad ..(12)$$

where f and F are functions of u only.

Substituting (12) in (11) we get

$$\frac{d}{du}\left\{3f^2+F^2\right\}=\tfrac{9}{2}\rho_0 U f \qquad ..(13)$$

i.e.,

$$6ff'+2FF'=\tfrac{9}{2}\rho_0 U f \qquad ..(14)$$

where dashes denote differentiation with respect to u.

Substituting (12) in (10)

$$\sigma\rho_0 \mathrm{U} f\frac{di}{du}=f\frac{\partial}{\partial u}\left(f\frac{di}{du}\right)+\frac{4}{9}\mathrm{F}\frac{\partial}{\partial u}\left(\mathrm{F}\frac{di}{du}\right)$$

$$=\left(f^2+\frac{4}{9}\mathrm{F}^2\right)\frac{d^2i}{du^2}+\left(ff'+\frac{4}{9}\mathrm{FF}'\right)\frac{di}{du}$$

Substituting the value of $\rho_0 \mathrm{U} f$ from (14) this equation becomes

$$\frac{d^2i}{du^2}+\frac{ff'\,(1-\frac{4}{3}\sigma)+\frac{4}{9}\,\mathrm{FF}'\,(1-\sigma)}{f^2+\frac{4}{9}\,\mathrm{F}^2}\,\frac{di}{du}=0$$

By virtue of (7) and since $\frac{di}{du}$=constant, this equation will be satisfied only if

$$ff'\left(1-\frac{4}{3}\sigma\right)+\frac{4}{9}\,\mathrm{FF}'\,(1-\sigma)=0 \qquad ..(15)$$

Integrating it we get

$$f^2\left(1-\frac{4}{3}\sigma\right)+\frac{4}{9}\,\mathrm{F}^2\,(1-\sigma)=\mathrm{B} \qquad ..(16)$$

where B is constant of integration to be determined.

Again since

$$\frac{\partial}{\partial y}\frac{\partial\psi}{\partial x}=\frac{\partial}{\partial x}\left(\frac{\partial\psi}{\partial y}\right)$$

i.e.,

$$\frac{\partial}{\partial u}\left(\frac{\partial\psi}{\partial x}\right)\frac{\partial u}{\partial y}=\frac{\partial}{\partial u}\left(\frac{\partial\psi}{\partial y}\right)\frac{\partial u}{\partial x}$$

Hence using (8) and (12) it becomes

$$\tfrac{2}{3}\, f'\,\mathrm{F}=\mathrm{F}' f$$

which on integration gives

$$\mathrm{F}=\mathrm{A} f^{\frac{2}{3}} \qquad ..(17)$$

Substituting (17) in (16) we get

$$f^2\left(1-\frac{4}{3}\sigma\right)+\frac{4}{9}\mathrm{A}^2 f^{\frac{4}{3}}(1-\sigma)=\mathrm{C} \qquad ..(18)$$

Let us now expand $f(u)$ in ascending powers of u and neglecting squares and higher powers of u we are justified in writing

$$f=a+bu \qquad ..(19)$$

Then

$$f^{\frac{4}{3}}=(a+bu)^{\frac{4}{3}}=a^{\frac{4}{3}}\left(1+\frac{4}{3}\,\frac{b}{a}u\right) \qquad ..(20)$$

neglecting square and higher powers of u.

Hence using the expressions (19) and (20), equation (18) becomes

$$\left(a^2+2\,abu\right)\left(1-\frac{4}{3}\sigma\right)+\frac{4}{9}\mathrm{A}^2\,a^{\frac{4}{3}}\left(1+\frac{4}{3}\,\frac{b}{a}u\right)\left(1-\sigma\right)=\mathrm{C}$$

Comparing the constants and the coefficient of u on both sides we get

$$a^2\left(1-\frac{4}{3}\sigma\right)+\frac{4}{9}\mathrm{A}^2\,a^{\frac{4}{3}}\left(1-\sigma\right)=\mathrm{C} \qquad ..(21)$$

$$2\,ab\left(1-\frac{4}{3}\sigma\right)+\frac{4}{9}\,A^2\,a^{\frac{4}{3}}\,\frac{4}{3}\,\frac{b}{a}\left(1-\sigma\right)=0 \qquad ..(22)$$

Solving (21) and (22) we get

$$A^2=\frac{9}{8}\,\frac{4\sigma-3}{1-\sigma}\,a^{\frac{2}{3}} \qquad ..(23)$$

$$C=\frac{1}{6}\left(4\sigma-3\right)a^2 \qquad ..(24)$$

Integrating (13) we get

$$3\,f^2+F^2=\frac{9}{2}\rho_0\,U\int f\,(u)\;du+D \qquad ..(25)$$

Substituting

$$f=(a+bu),\ F=Af^{\frac{2}{3}}=A(a+bu)^{\frac{2}{3}}$$

and neglecting squares and higher powers of u, (25) becomes

$$3\,(a^2+2ab\,u)+A^2\,a^{\frac{4}{3}}\left(1+\frac{4}{3}\,\frac{b}{a}u\right)=\frac{9}{2}\rho_0\,U\,au+D$$

Comparing constant terms and coefficients of u, we get

$$3\,a^2+A^2\,a^{\frac{4}{3}}=D \qquad ..(26)$$

$$6\,ab+\frac{4}{3}\,\frac{b}{a}\,A^2\,a^{\frac{4}{3}}=\frac{9}{2}\rho_0\,Ua \qquad ..(27)$$

Equations (26) and (27) with the help of (23) give

$$b=3\,(1-\sigma)\,\rho_0\,U \qquad ..(28)$$

and

$$D=\frac{3}{8}\,\frac{4\sigma-1}{1-\sigma}\,a^2 \qquad ..(29)$$

Now (23), (24), (28), (29) give all the constants in terms of a and the Prandtl number σ.

Thus $$f\,(u)=a+3\,(1-\sigma)\rho_0\,Uu \qquad ..(30)$$

The constant a is arbitrary and these equations are not sufficient to give the value of a.

Turning back to the equations (8) and (12) we get

$$\frac{\dfrac{\partial u}{\partial x}}{\dfrac{\partial u}{\partial y}}=\frac{\dfrac{\partial\psi}{\partial x}}{\frac{2}{3}\dfrac{\partial\psi}{\partial y}}=\frac{f}{\frac{2}{3}F}=\frac{f}{\frac{2}{3}\,A\,f^{\frac{2}{3}}}$$

$$=\frac{(a+bu)}{\frac{2}{3}\sqrt{\left\{\frac{9\,(4\sigma-3)}{8\,(1-\sigma)}\right\}}\;a\left(1+\frac{2}{3}\,\frac{b}{a}U\right)}$$

$$=\frac{\sqrt{2}\left(1+\frac{b}{a}U\right)}{\sqrt{\left(\frac{4\sigma-3}{1-\sigma}\right)}\left(1+\frac{2}{3}\,\frac{b}{a}U\right)}$$

Neglecting the terms of the type $u\frac{\partial u}{\partial x}$ and $u\frac{\partial u}{\partial y}$ we get

$$\frac{\partial u}{\partial x}=\lambda\frac{\partial u}{\partial y} \qquad ..(31)$$

where
$$\lambda=\sqrt{\frac{2\,(1-\sigma)}{4\sigma-3}}$$

Now the solution of (31) is

$$u=f\,(y+\lambda x) \qquad ..(32)$$

This gives the disturbance, constant λ depending on one parameter σ, the Prandtl number. Ray[1] and the present author, in his previous paper, both have calculated the value of λ which is slightly different. The difference is that in the numerator under the radical sign there is 3 instead 2 as calculated here. This does not affect the results thus obtained.

*It has come to the notice of the author (at the time of reading the proof pages) that the same problem has been investigated by Kapur.[2] But on comparing the results the author found that the method followed by him is quite different. Not only this but equations (21), (22), (23), (24), (25), (26), (27), (28), (29), of Kapur[2] contain some errors affecting the results. The value of a obtained by Kapur[2] in the form $1-\sigma$ is also not correct. It remains arbitrary constant and can not be found in the form of $1-\sigma$ as obtained by Kapur.

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* Matter added in proof.

PRESSURE VARIATION IN HYDROMAGNETIC FLOW BETWEEN TWO PARALLEL PLANE POROUS WALLS

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INTRODUCTION

The steady flow of an electrically conducting, incompressible viscous fluid of constant electric and magnetic properties in the space between two parallel porous, infinite plane walls in the presence of transverse magnetic field has been studied by Agrawal and Agrawal (Ref. 1) when a constant pressure gradient exists in the direction of flow. In this note we have studied the transverse and longitudinal pressure variations. The present work reveals that the pressure variations in the transverse direction depends on the cross flow, unlike that in the absence of the magnetic field.

GOVERNING EQUATIONS

Since this problem has been dealt with in Ref. 1, the Governing Equations, Symbols, assumptions, their simplifications and boundary conditions are the same as in Ref. 1. We start with equation (22) to discuss the pressure variation in this problem which has not been dealt with in Ref. 1.

PRESSURE VARIATION

Equation which gives pressure variation in the flow region (Equation 22 ref. 1).

$$p(x,z)+P_x+\frac{M}{8\pi}H^2x=\text{Constt.} \qquad (1)$$

and also

$$p(x,L)+P_x=\text{Constt.} \qquad (1a)$$

Since at $\bar{Z}=L$ and $H_x(L)=0$ from the boundary conditions (Equation 23 ref. 1).

On subtraction

$$p(x,L)-p(x,z)=\frac{M}{8\pi}H^2x \qquad (2)$$

which gives pressure variation in transverse direction.

Again in longitudinal direction

$$p(o,z)+\frac{M}{8\pi}H^2x=\text{Constt.} \qquad (1b)$$

Now subtracting Equation (1) from (1b)

$$p(o,z)-p(x,z)=P_x \qquad (3)$$

The value of H_x is given by the equation (37) (Ref. 1) from which it can be observed that H_x depends on the magnitude of Vo, the cross flow, as well as its sign (direction).

When the electric conductivity tends to zero, there will exist no current in the field and hence the flow will not interact with the magnetic field (Limiting case 2 of ref. 1) and in this case $H_x \rightarrow 0$.

From Equation (2) it is readily seen that, pressure decreases as we move from either wall towards the centre of the channel, and pressure variation in the transverse direction depends on the magnitude and direction of the cross flow. It is interesting to note that in the absence of magnetic field there is no pressure variation in transverse direction whatever be the magnitude and direction of cross flow. Again equation (3) gives that pressure variation in longitudinal direction as we move in the direction of (longitudinal) flow pressure goes on decreasing.

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ROTATORY POWER OF BRUCINE DERIVATIVES OF SOME ISONITROSO KETONES

PART II—BRUCINE DERIVATIVES OF α-CHLORO-α-ISONITROSO-P-METHYL ACETOPHENONE AND α-BROMO-α-ISONITROSO-P-METHYL ACETOPHENONE

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ABSTRACT

Brucine derivatives of α-chloro-α-isonitroso-p-methyl acetophenone and α-bromo-α-isonitroso-p-methyl acetophenone have been prepared and their rotatory power determined in chloroform and pyridine. Determination of the rotatory power for twelve different wavelengths in the visible region of the spectrum indicated that the nature of the dispersion is simple. The effect of different substituents on optical rotatory power in these derivatives has been discussed.

INTRODUCTION

In a previous communication[1] the authors described the rotatory power of brucine derivatives of isonitroso acetophenone, α-chloro-α-isonitroso acetophenone and α-bromo-α-isonitroso acetophenone. In this paper the work has been extended to the brucine derivatives of α-chloro-α-isonitroso-p-methyl acetophenone and α-bromo-α-isonitroso-p-methyl acetophenone with a view to study the effect of -Cl, -Br and $-CH_3$ groups situated not in the immediate vicinity of optically active centre in these derivatives.

EXPERIMENTAL

The isonitroso ketones required were prepared by the method described earlier.[2] The brucine and the isonitroso ketones readily condensed when mixed in equimolecular proportions in ethanol or ethanol-chloroform mixture to yield salt like compounds. The characteristics of the compounds obtained are summarised below.

Brucine derivative of α-chloro-α-isonitroso-p-methyl acetophenone:

It is a white crystalline solid. M. P. 251°C.

Found : C=58·00%; H=6·45%; N=6·65%;

$C_{32}H_{34}O_6N_3Cl.4H_2O$ requires C=57·87%; H=6·33%; N=6·31%. It is soluble in chloroform and pyridine but practically insoluble in water, methanol, ethanol, ethyl acetate, benzene, acetone, carbon tetrachloride, dekalin, dioxan, ether and petroleum ether.

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Brucine derivative of α-bromo-α-isonitroso-p-methyl acetophenone:

It is a light yellow crystalline solid. M. P. 278°C.

Found : C=55·14%; H=6·47% and N=5·48%

$C_{32}H_{34}O_6N_3Br.H_2O$ requires C=54·2%; H=5·90%; N=6·42%. Its solubility was found to be similar to that of brucine derivative of α-chloro-α-isonitroso-p-methyl acetophenone.

The rotatory power measurements were carried out in a 2 dcm tube using twelve different wavelengths in the visible region of the spectrum. The observations are recorded in table 1.

The rotatory dispersion data given in table 1 was analysed according to usual methods. On plotting $1/(\alpha)$ against λ^2 a straight line was obtained[1] in both cases indicating that these compounds exhibit simple dispersion. The dispersion equations were calculated and have been given in Table 1. The calculated values from proposed dispersion equation and those observed were found to be in close agreement.

TABLE 1

Rotatory power of brucine derivatives of isonitroso ketones described in this paper.

Brucine derivative of:	α-chloro-α-isonitroso-p-methyl acetophenone		α-bromo-α-isonitroso-p-methyl acetophenone	
Solvent	Chloroform	Pyridine	Chloroform	Pyridine
Conc. in g./100 ml	1·1100	1·1232	1·0068	1·0300
Temperature in °C	19·5	20	22	22
Calculated dispersion equation $(\alpha)\lambda=$	$-\frac{2\cdot567}{\lambda^2-0\cdot1439}$	$-\frac{3\cdot791}{\lambda^2-0\cdot1484}$	$-\frac{2\cdot234}{\lambda^2-0\cdot1315}$	$-\frac{5\cdot511}{\lambda^2-0\cdot1057}$
Wavelength (λ)	Obs. $(\alpha)\lambda$	Obs. $(\alpha)\lambda$	Obs. $(\alpha)\lambda$	Obs. $(\alpha)\lambda$
Hg 4358	−55·85°	...	−38·23°	−65·04°
Li 4603	38·28	−60·98°	27·81	51·94
Cd 4678	34·23	53·86	25·82	48·54
Cd 4800	29·72	46·29	22·34	43·68
Cd 5086	22·52	34·72	17·38	35·92
Hg 5461	16·66	25·37	13·40	28·64
Hg 5780	13·51	20·47	10·92	24·27
Na 5893	12·61	19·14	10·42	22·81
Li 6104	11·26	16·91	9·43	20·87
Ne 6402	9·90	14·69	8·44	17·96
Cd 6438	9·45	14·24	7·94	17·47
Li 6708	8·55	12·46	6·95	16·01

DISCUSSION

In table 2 the rotatory power of these derivatives has been compared. In this table the specific rotatory power and molecular rotatory power (*i. e.*, 1/100th of molecular wt x sp. rotation) of these compounds has been recorded with a view to bring out the comparison vividly.

TABLE 2

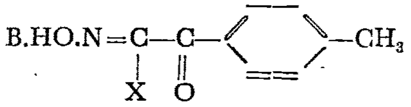
Comparison of rotatory power.

Name B=Brucine	Specific rotation for Hg 5461		Molecular rotation for Hg 5461	
	Chloroform	Pyridine	Chloroform	Pyridine
1. B-isonitroso acetophenone	18·75	34·51	123·8	227·8
2. B-α-Chloro-α-isonitroso acetophenone.	11·63	28·94	79·84	198·6
3. B-α-Chloro-α-isonitroso-p-methyl acetophenone	16·66	25·37	110·5	168·3
4. B-α-Bromo-α-isonitroso acetophenone.	18·59	29·12	122·3	191·6
5. B-α-Bromo-α-isonitroso-p-methyl acetophenone.	13·40	28·64	87·62	187·3

Note : Compounds (1), (2) and (4) have been described earlier.[1]

If we compare the rotatory power of brucine derivative of α-bromo-α-isonitroso acetophenone and brucine derivative of α-bromo-α-isonitroso-p-methyl acetophenone we find that the introduction of -CH_3 in place of -H in the benzene part of the molecule causes a lowering in the magnitude of rotatory power. However, when a comparison is made of the rotatory power in the case of brucine derivative of α-chloro-α-isonitroso acetophenone and brucine derivative of α-chloro-α-isonitroso-p-methyl acetophenone we find a similar decrease in pyridine but a slight increase in chloroform.

The groups -Cl, -Br and -CH_3 have an electronegative character as compared to -H, the electronegativity decreasing in the order -Cl>-Br>-CH_3. These groups occupy a position which is not in the immediate vicinity of the asymmetric centre. It is nevertheless noticeable that their general effect is to cause a lowering in the magnitude of the rotatory power. The -CH_3 group which is further removed from the asymmetric centre is normally expected to have a lesser influence on the magnitude of rotatory power. In these compounds, however, it can transmit its effect to the -Cl or -Br groups through a system of conjugated bonds as shown in the formula below :



Where X=Cl or Br. The dipoles of $C-X$ and $C-CH_3$ are not acting in the same direction and so the effect would not be expected to be very great. Since these are polar groups the dipole of the polar solvent such as chloroform and pyridine used here would also interefere with their electrical character.

In earlier studies of similar type the effect of introduction of methyl group was found to cause a lowering in the magnitude of rotatory power even though the methyl group was situated at not a negligible distance from the asymmetric centre. Singh, Bhaduri and Barat[3] found a decrease in the rotatory power in the case of amino derivatives of oxymethylene camphor, and Singh, Perti and Singh[4] found similar results in the case of amino derivatives of Reychler's acid. Perti and Pant[5] studied the rotatory power of strychnine salts of benzoic acid and p-toluic acids in pyridine and chloroform. These compounds are very similar to the compounds under discussion here in so far as their molecular set up giving rise to optical activity is concerned. The effect of substitution of $-CH_3$ in place of $-H$ in the benzene part of these molecules was found to cause a lowering in the magnitude of the rotatory power though the quantitative differences were not very pronounced. These results are in conformity with the views advanced by Singh and Barat[6] that the polarity of a group has noticeable effect on optical rotatory power and that the introduction of an electronegative group would generally cause a decrease in the magnitude of rotatory power.

Here we find that the effect of the two electronegative groups $-Cl$ and $-CH_3$ or $-Br$ and $-CH_3$ when persent together is generally to cause a lowering in the magnitude of the rotatory power. These are, however, polar groups and their individual dipoles are not acting in the same direction. Moreover, the solvents suitable for measurement of rotatory power happen to be also highly polar. Under these circumstances the polar effect of the groups cannot be expected to be very well defined. Nevertheless the effect is noticeable as pointed out earlier in the discussion.

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CHEMICAL ANALYSIS OF THE MINERAL CONTENT OF SOME FRUITS OF KUMAON REGION

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INTRODUCTION

A reference to the literature shows that no chemical analysis regarding the mineral content of the fruits of Kumaon has been carried out so far. Further the estimation of trace elements like Mn, Cu and Zn etc., have not been made in many of the fruits elsewhere also. Hence it was considered necessary by us to undertake a systematic chemical analysis of the mineral, vitamin and amino acid contents of some of the fruits of Kumaon at different stages of ripening, and after storage. This paper presents the data obtained in the preliminary investigation regarding the mineral content of peach, apricot, strawberry, plum, teed tomato and tomato. The data, in each case, refer to the fresh ripe fruits.

EXPERIMENTAL

Before preparing the solution for analysis, the fruits after thorough washing were weighed and the rind was taken out and then weighed again. The weight of the fruit after taking out the rind has been taken as the basis of calculation. The fruit, in each case, was then subjected to wet ashing with sulphuric, perchloric and nitric acids.[1]

After obtaining the clear solution by the above procedure, the colorimetric method of estimation was followed for determining the amounts of different minerals present. For doing this the calibration curve of extinction coefficient vs. concentration with a standard solution of each mineral salt was drawn. For colorimetric measurements, a Lange's Photo-electric colorimeter with suitable filters was used. The methods followed for colorimetric estimation of different mineral salts were as follows:—

Calcium was estimated as calcium oxalate, Phosphorus by the molybdenum blue method; Iron as ferric by potassium ferrocyanide method potassium by sodium cobaltinitrate method; magnesium by titan yellow method; manganese as permanganate by persulphate method; copper by rubeanic acid method; zinc by dithizone method, and cobalt by α-nitroso-β-naphthol method. The details of the method followed are described by Snell and Snell.[1]

OBSERVATIONS

The amounts of different minerals in the fruits investigated are tabulated below in mgms. per 100 gms. of the fruit.

TABLE

Mineral contents of some fruits of Kumaon Region in mgm./100 gm. of the fruit.

Name of the fruit	Ca	P	K	Mg	Fe	Cu	Zn	Mn	Co.
Peaches	16	24	85	4·6	0·38	0·22	0·36	0·15	0·13
Apricots	15	26	82	3·85	0·32	0·26	0·43	0·29	0·23
Strawberries	43	29	99	11·50	0·85	0·32	0·46	0·39	0·32
Plums	22	34	100	7·50	0·56	0·33	0·45	0·31	0·27
Teed-Tomato	13	27	97	3·50	0·439	0·23	0·39	0·19	0·21
Tomato	12	26.5	93	4·30	0·41	0·25	0·40	0·16	0·19

A comparision of the above values with those for the same European fruits regarding calcium, phosphorus and iron (for which only the data is available)[2] shows that the above fruits of Kumaon have almost the same amount of calcium, phosphorus and iron as found in the European fruits of the same species.

Further work to confirm the above findings by polarographic analysis and to determine the variation of different mineral contents during the process of ripening is in progress.

ACKNOWLEDGEMENTS

We are grateful to the authorities of Th. D. S. B. Government college, Naini Tal (India) for providing the necessary facilities to undertake this investigation and one of us (Mahendra Pal) is grateful to C. S. I. R., New Delhi for the award of Junior Research fellowship to undertake this work.

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CONCENTRATION OF RECEIVED ENERGY NEAR M. U. F.

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Enhancement of intensity of short wave radio signals prior to cessation has been reported by a number of Ionospheric workers.[1-4] Banerjee and his collaborators have dealt in detail the various causes of cessation of short wave radio signals at various hours of the day. The fading patterns obtained prior to disappearance have, however, not been studied in detail. The purpose of this communication is to discuss the probable cause of the enhancement of the intensity.

Disappearance patterns are obtained as a result of interference between the upper and lower extraordinary waves. Few such patterns taken at B.H.U., Varanasi are given in figure Nos. 1—5. A look at these patterns will show which of the component waves is gradually increasing. Fig. 1 indicates that the strength of the lower angle wave (which was comparatively very strong in the beginning) is constant throughout the pattern, and the intensity of the upper extraordinary wave has increased due to which there is gradual increase in the depth of fading. Disappearance fading pattern given in fig. 2 shows that there had been an increase in the intensity of both the upper and lower extraordinary waves. It should be mentioned, however, that the total path travelled by the lower angle wave increases as it approaches the M. U. F., whereas the path travelled by the upper angle wave decreases. This enhancement of the intensity of the lower angle wave when there is increment in path, is against the general expectation that as the path travelled by the wave increases, there should be decrease in the intensity due to inverse distance effect and the attenuation in the extra path. Further, this fact leads one to think that the enhancement of the upper angle wave as M. U. F. is approached may also not be mainly due to decrease in attenuation for the reduced path and the inverse distance effect. It must be noted that these discussions are for the conditions just before disappearance and as such it may be assumed that the maximum path difference involved between the upper and lower angle wave will be confined to about 100 wavelengths only. This enhancement of the intensity may be attributed to the concentration of the received energy near M.U.F., an idea of which can be had from the slope of the (D, i) curves (fig. 6). The discussion below will show how from the slope of the (D, i) curves one can infer about the concentration of the received energy as M.U.F. is approached. (D, i) curve for the extraordinary may be drawn with the help of simplified equation developed by Mehrotra but for the sake of the convenience of drawing the (D, i) curves, use has been made of the formula for D in the absence of the magnetic field. It may, however, be noted that such concentration of energy is also observed at the time of disappearance of the ordinary wave.

The fundamental equation connecting (D) and (i) is given by

$$D = Y_m \frac{f}{f_c} \sin i_0 \log \frac{f + f_c \cos i_0}{f - f_c \cos i_0} + 2\, h_0 \tan i_0 \qquad (1)$$

Taking certain values of Y_m, f, f_c and h_o, a graph showing the relation between D and i can be drawn. Fig. 6 represents such a graph drawn for the values of Y_m and h_o as 50 kms and 300 kms respectively. The ratio f/f_c is taken to be 1·1. It can be seen that for each value of D, there are two values of i_o, one corresponding to the lower angle wave and the other corresponding to the upper angle wave. The part OP of the curve represents the upper angle wave whereas the part OR corresponds to the lower angle wave. It will be observed that OP is comparatively sharp and meets the curve for the lower angle wave at a point corresponding to the skip distance. In fig. 6 small angular elements, each subtending an angle ($d\theta$) at the transmitter have been taken and the corresponding distances (regions) in which the energy of each such elements is spread over have been indicated. These small angular elements ($\delta\theta$) are taken at equally spaced angles on both the sides of the skip angle (ϕ) shown in fig. 6. Let A and B represent two such angular elements at equal interval of angles on both the sides of the skip angle ϕ. It may be seen that the energy contained in these two angular elements spreads over the distances d_1 and d_1', which are nearly equal. Take the next two angular elements represented by C and D, the energies of which are spread over the distances d_2 and d_2', respectively. In this case there is considerable difference in the spreading of energy. The energy contained in the angular element C spreads over a distance of 5 Kms whereas the energy of the angular element D spreads over a distance of 1 Km only. The energy of the angular element D, however, spreads over a greater distance than the energy of the angular element B. It may be noted that both the angular elements B and D correspond to the lower angle wave. The spreading of the energy is too marked in the case of the upper angle wave, as is evident from the spreading of the energy contained in the angular elements A, C and E into distances d_1, d_2 and d_3 equal to 1/2, 5 and 14 Kms. respectively. The spreading of energy in the case of lower angle wave is marked only near the end. The two curves nearly become horizontal at the point where they meet each other; as such there will be no change in spreading of the energy very near to skip point. The above mentioned facts may be summarised as follows. Due to parabolic distribution of the electronic density in the Ionosphere, concentration of the received energy of both the upper and lower waves increase as the skip distance is approached. The increase in concentration is marked in the case of upper angle wave. This explains the enhancement of the intensity of the individual interfering waves as M. U. F. is approached and further it also explains why this enhancement of the intensity is too marked in the case of the upper angle wave.

In the above discussion, Ionospheric conditions were assumed to be constant and the variation of the intensity of the received radio signals as the distance between the transmitting and receiving stations increased was considered. In actual practice, however, the distance between the transmitter and receiver remains constant and the approach of the skip point at the receiving station is obtained as a result of decrease in M. U. F. which may take place as mentioned earlier due to decrease in electronic density or due to expansion of the ionized region.

Further work in this direction is in progress and the result of the investigation will be communicated shortly.

ACKNOWLEDGEMENTS

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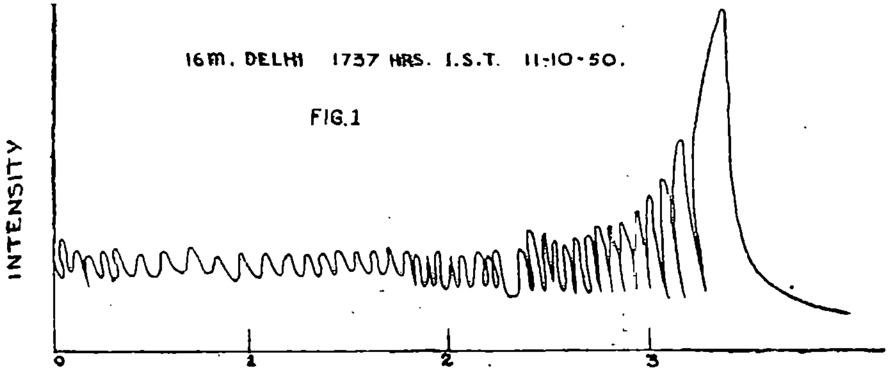

16m. DELHI 1737 HRS. I.S.T. 11-10-50.

FIG.1

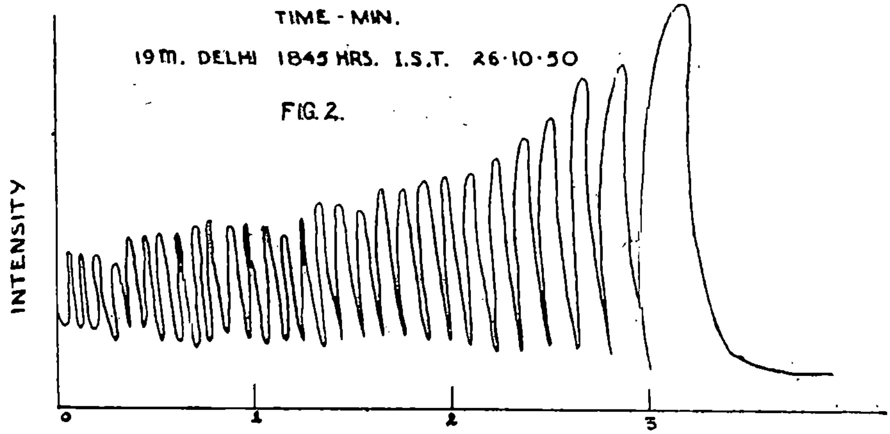

19m. DELHI 1845 HRS. I.S.T. 26-10-50

FIG. 2.

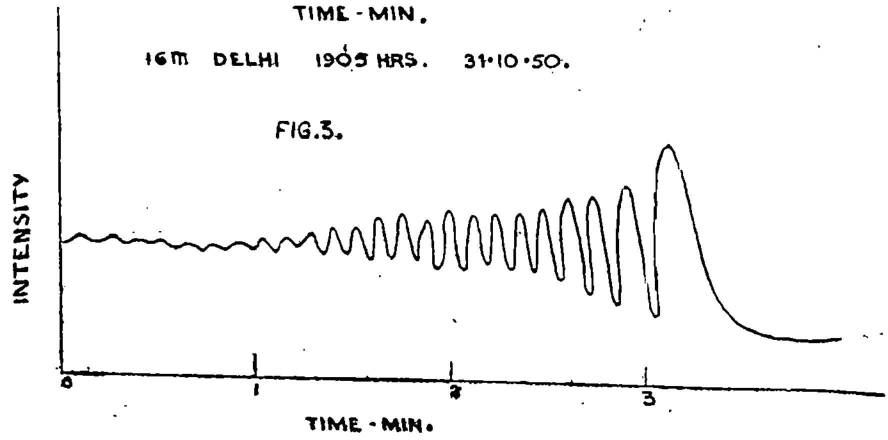
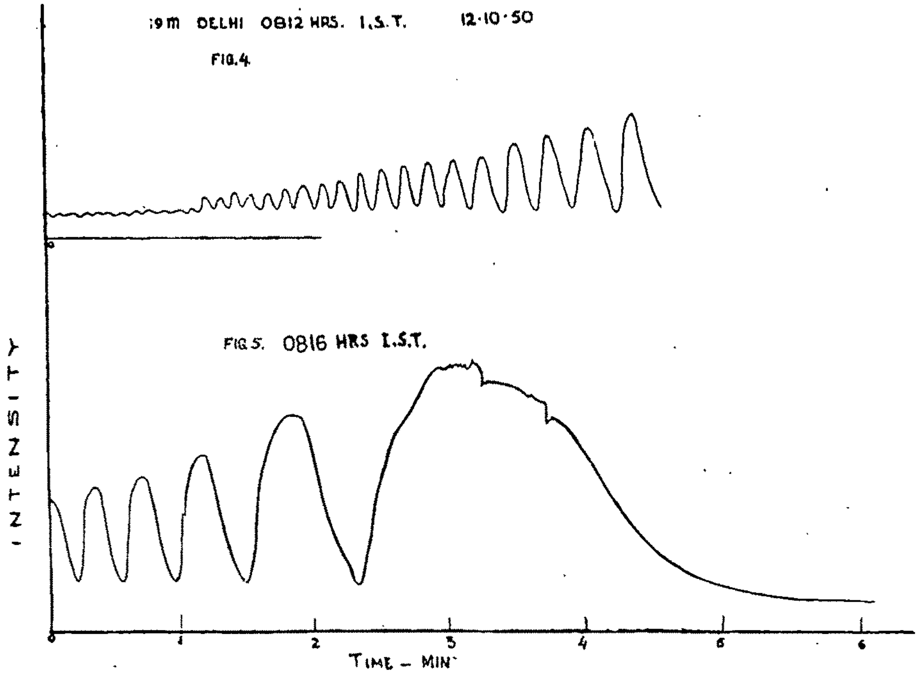

16m DELHI 1905 HRS. 31-10-50.

FIG.3.


19m DELHI 0812 HRS. I.S.T. 12·10·50
FIG.4.
FIG.5. 0816 HRS I.S.T.
INTENSITY
0
1
2
3
4
5
6
TIME – MIN

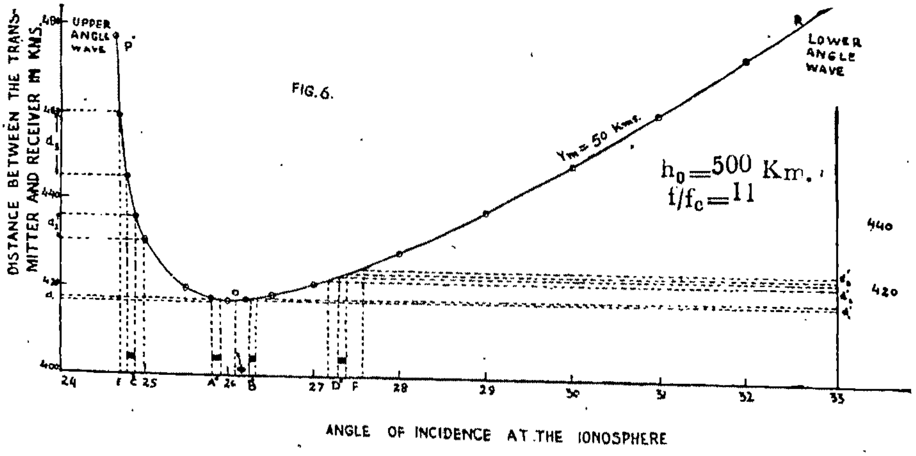


FIG.6.
DISTANCE BETWEEN THE TRANSMITTER AND RECEIVER IN KMS.
UPPER ANGLE WAVE
P
LOWER ANGLE WAVE
R
$Y_m = 50$ Kms.
$h_0 = 500$ Km.
$f/f_c = 1.1$
440
420
400
24
E
C
25
A
26
B
27
D
F
28
29
30
31
32
33
ANGLE OF INCIDENCE AT THE IONOSPHERE

STUDY OF STRUCTURAL BEHAVIOUR OF COSMIC RAY AIR SHOWERS AT NAINI TAL

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SUMMARY

When an energetic cosmic ray primary enters the atmosphere of earth, it produces energetic collisions with the nuclei of nitrogen and oxygen at various stages on its way. From these collisions, a large number of π-mesons along with some K-mesons and nucleons-antinucleon pairs are produced. The π°-mesons produced in such events which decay instantaneously into γ-rays, start a rapidly growing electron-photon cascade. A shower of secondary electrons and photons along with a small fraction of π-meson, K-meson and other heavier particles is produced corresponding to every energetic primary that enters the atmosphere. These showers which consist of millions of secondary particles at the ground level, arriving almost simultaneously, can be detected by a suitable arrangement of counters.

A study of these showers gives useful information about the general behaviour of the nuclear as well as electro-magnetic processes in which showers are produced. An attempt was made to study certain gross features of air showers in the energy interval $5{\cdot}4 \times 10^{14}$ to 2×10^{16} e. volts. In order to study the behaviour of nucleonic collisions, shower rates have been correlated with the atmospheric fluctuations.

Certain average properties like solar variations, barometric coefficients, absorption mean free path of collisions, inelasticity parameters, energy exponent and sidereal fluctuations have been experimentally investigated. Some miscellaneous experiments regarding the nonlinearity of photo-multipliers, design of a large area liquid scintillation counter and study of the uranyl salt solutions for their use in scintillation counters has also been given at the end.

Showers of six different energies in the interval $3{\cdot}07 \times 10^{15}$ to 2×10^{16} e. volts have been selected by G.M. counter arrays which were set up for this purpose. The necessary electronic equipments were rigged up by us in the laboratory. Showers were recorded in solar time in two groups of particle densities. Showers of energy $3{\cdot}07 \times 10^{15}$, $5{\cdot}07 \times 10^{15}$ and $8{\cdot}9 \times 10^{15}$ e. volts were recorded with G.M. counters which were sensitive to 20 particles per sq. m. and showers of energy $6{\cdot}14 \times 10^{15}$, $1{\cdot}02 \times 10^{16}$ and $1{\cdot}78 \times 10^{16}$e. volts were recorded with counters that were sensitive to 40 particles per sq.m. When these showers were harmonically analysed, they yielded significant solar amplitudes for the first as well as second harmonics. The solar amplitude recorded with particle densities$=$20 particles per sq. m. were larger than those recorded

with 40 particles per sq. m. The amplitudes were also found to increase with the energy of the showers.

The effect of a local absorber on shower particles was investigated. It was found that shower rates were greatly attenuated even by a few gms. cm.$^{-2}$ of matter over the counters and by putting about 25 gms. cm.$^{-2}$ of water absorber the shower rates were decreased to a constant level where mostly μ-mesons were responsible for the selection of showers. 40,000 showers were selected in one particular array under absorbers (=30 gms. cm.$^{-2}$). The analysis of these showers gave a negligible solar variation.

Pressure fluctuations over Naini Tal were continuously recorded by a barograph. The data of thirteen months record gave the following pressure harmonic amplitudes :—

$$P_1 = 0{\cdot}32 \text{ Sin. } (t+186^\circ)$$
$$P_2 = 1{\cdot}40 \text{ Sin. } (2t+56^\circ)$$

P_1 and P_2 are given in gm. cm.$^{-2}$. A systematic opposite correlation was found between the solar rates of showers and the local atmospheric fluctuations. The pressure coefficients or the barometric coefficients were determined for the six different energies of showers recorded in solar time. The absorption length or the absorption mean free path of the showers which is approximately given by; $B = \frac{1}{\Lambda}$ was calculated. The values of B in this energy region were found to be $\approx 13{\cdot}5\%$ to 15% for the three-fold events and 19% to 20% for the four-fold events. The corresponding values of Λ range from 90 to 100 gm. cm.$^{-2}$ for the first group and are approximately 70 gm. cm.$^{-2}$ for the second group of showers recorded under four-fold selection. These results have been compared to those found earlier by other workers.

The inelasticity of collisions was also correlated with the values of Λ measured in this experiment. It was found that the energy retained by the nucleon in energetic collisions was fortyfive to fifty% of the incident energy. The result of this behaviour will be such that at higher energies $\geqslant 10^{16}$e. volts higher solar amplitudes may be recorded. The first generation π°-mesons in these cases will get a share of energy of the primary which will be of the order of 10^{14}e. volts and the corresponding electro-magnetic cascades due to the first generation π°-mesons will be able to reach the ground level or mountain altitude. The showers recorded corresponding to an energy $\geqslant 10^{16}$e. volts may progressively show higher and higher solar harmonic amplitude and pressure coefficients as has been observed by us and by some other workers as well.

The flux of primary cosmic radiation producing air showers has been measured. The approximate effective area to which the different arrays were sensitive has been defined. The average solid angle from which the showers arrive at the recording arrays has been calculated from the pressure coefficients measured. A mean value of 0·15 per cm. of Hg. has been used. The value of the energy exponent has been found to change from 1·7 to 2·15 in the energy region 3×10^{15}e. volts to 2×10^{16}e. volts. These observations are nearly consistent with the scintillation counter measurements of G. Clark and B. Rossi. The consequences of the change in the energy exponent have been discussed.

Showers have also been selected for a sidereal analysis under two different conditions. 40,000 showers selected with $\approx$30 gms. cm.$^{-2}$ absorbers over trays have yielded a good sidereal correlation. These showers were shown to be less dependent on solar fluctuations and the sidereal fluctuation, if present, will not be disturbed in the case of these showers. A harmonic analysis of the showers gave a first harmonic amplitude$=(2{\cdot}34\pm0{\cdot}7)\%$ at 20·4 hours local sidereal time. This is the time when the galactic centre is over-head at Naini Tal. The other two groups of showers were selected without any absorber and were dependent on solar fluctuations. They have given large false amplitudes mostly due to the influence of solar fluctuations. The condition of the primary energy spectrum at supper-high energies in the light of these small anisotropies at 10^{15}—10^{16}e. volts has been examined. The present result has been compared with the observations of other workers also.

Photo-multipliers 5819, IP28,931—A and 6364 have been studied from the point of view of their nonlinear behaviour for large electron currents. It has been found that when the electron current is increased, a marked change in the interdynode potentials takes place. After a certain stage these fluctuations become erratic followed by a break down even though the over-all voltage remains well stabilised. The safe limit for current for these photo-multipliers *i.e.*, 5819, IP28, 931—A and 6364 for a linear behaviour is 25μ.amps., 25μ.amps, 40μ.amps. and 150μ.amps. respectively. It was found that when the individual dynode potentials were stabilised by NE-2 neons the range of usefulness was increased several times.

A large area liquid scintillation counter designed for selection of the density of shower particles is discussed. Four similar counters have been built for the selection of $\geqslant10^{17}$e. volt showers. The counter has been calibrated for single particles and tested for its linear response to the particles entering at any position inside the active volume of the liquid. The light collection of the scintillation pulses is based on diffuse reflection so that when a light flash is produced at one position, the whole tank glows and becomes a source of light.

Uranium oxalate and nitrate solutions have been tried in liquid scintillation counter tank for their property of detection of single cosmic ray particles. The rise time and decay time along with the pulse amplitudes have been measured for these solutions corresponding to cosmic ray pulses by the help of a fast oscilloscope (Mod. Hp.—150 AR) and camera attachment.

A small note on a large area distilled water Cerenkov counter is also given at the end. All these counter techniques were perfected in this laboratory for being used in the future experiments.

MUSCULATURE STUDIES ON *SYRPHUS BALTEATUS* DE GEER (SYRPHIDAE : DIPTERA)*

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INTRODUCTION

The studies on the musculature of Diptera are perhaps most neglected. The only works of some importance include Lowne (1895) on the muscles of the proboscis of the blow fly; Hewitt (1914) on the musculature of the mouth parts of the house-fly; Grahamsmith (1930) on the functions of the proboscis of the blow fly; Williams (1913) on the flight muscles of *Drospohila melanogaster* Meigen, Tiegs (1955) on the flight muscles of *Drosophila repelata*, Miller (1950) on the musculature of *Drosophila melanogaster*; Smart (1958) on coxo-subalar muscles of the mesothorax of Diptera and Grant (1960) on the mesothoracic indirect flight muscles of Simulidae and Psychodidae. Mercier and Villencuve (1927) are the only workers to report the muscles governing the lunule of *Eristalis tenax* belonging to family Syrphidae. As such the present paper on the musculature of *Syrphus balteatus* is an attempt to fill up the lacuna in part in the field of musculature studies of the family Syrphidae.

MATERIAL AND METHOD

The material fixed in Bouin's fluid gave satisfactory results in the study of musculature. The muscles were easily distinguished by the acid fuchsin. For the study of the musculature of the proboscis, the legs, the wings and the genitalia dissections were done under the binocular microscope. Besides, the insects placed in rectified spirit after staining with 1% Eosin, with addition of methylsalicylate drop by drop at hourly intervels over a period of 4-5 days showed satisfactory results.

MUSCULATURE OF THE HEAD

The muscles of the head include the intrinsic and the extrinsic muscles of the head. The former have their origin and insertion within the head, while the latter arise internally from the head and get inserted on the appendages of the cranium. Both bring about the movement of the appendages of the head namely, the antenna and the proboscis.

Antennal muscles:

(*A*) *Extrinsic antennal muscles:*

(i) *An antennal depressor* (fig. 2; 1) arises dorsally from the internal flange or ridge that strengthens the cranial rim of the eye and is inserted on the outer

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angle of the proximal rim of the first antennal segment. The contraction of this muscle lowers the antenna downwards.

(ii) *Antennal levator* (2) which is the antagonistic of the depressor of the antenna arises from the tentorium and is inserted on the inner angle of the proximal rim of the scape. The contraction of this muscle tends to raise the the antenna.

Of the two extrinsic muscles, the antennal depressor is stouter than the antennal levator. It is interesting to point out here that the origin of the antennal depressor is not on the tentorium a fact commonly known in adult pterygote insects reported by various authors, but from internal flange surrounding the eye.

(B) *Intrinsic antennal muscles:*

(i) *The antennal adductor* (3) arises on the inner side of the scape and becomes inserted on the inner angle of the basal rim of second antennal segment or the pedicel. The contraction of this muscle moves the antenna inwards.

(ii) *The antennal abductor* (4) arises on the outer side of the scape and is inserted on the outer basal angle of the pedicel. The contraction of this muscle moves the antennae away from each other and thus it functions as an antagonistic of the antennal adductor.

Singh and Misra (1955) report two extrinsic and three intrinsic muscles in the antenna of *Pachydiplosis oryzae* Mani. Miller (1950), however, has mentioned two muscles only of the second antennal segment in *Drosophila.*

Muscles of the proboscis:

Since the proboscis is a composite structure formed by the fusion of the gnathal appendages, the study of the musculature is rather complex for the muscles have undergone a considerable modification and shifting of positions. Thirteen muscles are concerned in the intake of food and other movements of the proboscis. The distiproboscis is devoid of any muscles and only a single muscle (retractor of the furca) passes beyond the haustellum and all the other muscles are confined to the rostrum and the mediproboscis. Out of the thirteen muscles, four are *extrinsic* and nine *intrinsic* muscles.

(A). *Extrinsic muscles of the proboscis:*

(i) *Retractor of the fulcrum* (fig. 1; 5), a fairly well developed muscle arises from the antero-lateral angle of the oral fossa to get inserted on the proximal cornua of the fulcrum. The contraction of this muscle renders the fulcrum into a slightly horizontal position inside the basiproboscis.

(ii) *Retractors of the rostrum* (6) are the longest and the most powerful muscles comprising six fibres arising dorso-laterally from the occiput to become inserted in the posterior wall of the distal end of the rostrum. These run along the outer side of the salivary duct and their contraction assists in the retraction of the proboscis inside the head capsule. Hewitt (1914) described these as retractors of the haustellum in the house fly.

(iii) *First accessory retractors of the rostrum* (7) are comparatively weaker muscles of the rostrum and provide an additional assistance in the retraction of the proboscis. These arise on the Y-shaped apodemes formed by the flange and the subocular ridge to get inserted on the posterior wall of the rostrum near its base.

(iv) *Second accessory retractor of the rostrum* (8) arises from the lateral side of the occipital foramen and runs up to the distal part of the rostrum where it gets inserted on the posterior wall of the latter slightly proximal to the insertion of the retractor of the rostrum. This muscle has been referred to as the flexor of the haustellum by Lowne (1895) in *Musca* and Graham-Smith (1930) in *Calliphora.* In these cases it is inserted on the distal posterior surface of the fulcrum and brings about the flexion of the haustellum against the face of the rostrum. But in *S. balteatus* its position of insertion has become shifted to the posterior wall of the rostrum thereby changing its function.

(B) *Intrinsic muscles:*

(i) *Dilators of the pharynx* (9) are the most powerful muscles arising in the rostrum concerned chiefly with the suction of the food. They arise from the anterior border of the lateral walls of the fulcrum and are inserted on the longitudinal median ridge of the dorsal plate of the cibarium. These muscles are extremely broad, run obliquely and fill the entire cavity enclosed by the lateral walls of the fulcrum.

(ii) *Extensors of the haustellum* (10) rather weakly developed muscles arise from the distal cornua of the fulcrum and get attached on the outer surface of the labral apodeme. The contraction of these helps to straighten out the haustellum.

(iii) *Accessory extensors of the haustellum* (11) are strong but short muscles arising from the anterior distal margin of the lateral wall of the fulcrum and become inserted on the inner side of the labral apodeme. Hewitt (1914) termed these as the accessory flexors of the haustellum in *Musca,* Lowne (1895) reported these as retractors of the haustellum, Graham-Smith (1930) referred to them as adductors of the apodemes in *Calliphora.* The contraction of these powerful muscles, pulls the heads of the labral apodemes anteriorly and thus helps in extending the haustellum on the basiproboscis. In view of their function, one is not inclined to accept the interpretations of Lowne (1895) and Hewitt (1914) and these may be considered as the accessory extensors of haustellum. Graham-Smith (1930) also believes these to assist the extensors of the haustellum by adducting the heads of the apodemes.

(iv) *Flexor muscles of the labrum* (12) are fairly long and stout muscles arising from the anterior arch of the fulcrum, extending downwards to become inserted on the base of the labrum-epipharynx. The contraction of these flexes the labrum on the anterior surface of the rostrum.

(v) *Regulator of the salivary pump* (13) a thin fibre, arising from the posterior wall of the fulcrum near the base of the proximal cornua, is inserted on the antero-lateral surface of the small sac-like salivary pump lying in the distal part of the basiproboscis. The contraction of this muscle regulates the flow of the saliva. Graham-Smith (1930) called it 'Gracilis'.

(vi) *Dilators of labrum-epipharynx* (figs. 1 and 3; 14) are strongly developed muscles more like a fan, arising from the inner surface of the labrum to get inserted on the epipharyngeal groove and a few fibres also become attached to the transverse ridge dividing the labrum-epipharynx into a distal small segment and a larger basal segment. Their contraction lifts the epipharynx thereby increasing the cavity of the pre-oral canal.

(vii) *Retractors of the furca* (15) arise from the inner lateral surfaces of the disto-posterior part of the trough-shaped mentum or theca and are inserted on the lateral arms of the furca supporting the membranous labella. Contraction of these muscles helps in the outward rotation of the lateral arms of the furca thereby spreading the labellar lobes.

(viii) *Retractors of the paraphysis* (16) have been named as retractors of the discal sclerite by Hewitt (1914) and paraphysal muscles by Lowne (1895). In *S. balteatus* they are arising from the proximal half of the mentum and inserted on the distal portion of the paraphysis.

(ix) *Dilators of the Labial gutter* (17) have also been variously interpretted by different authors. Lowne (1895) and Graham-Smith (1930) named these as the transverse muscles of the haustellum in *Musca* and *Calliphora,* respectively while Hewitt (1914) referred these as dilators of labium-hypopharynx in *Musca domestica.* In *S. balteatus,* these arise from the inner median surface of the mentum and are inserted on the sclerotised distal part of the labial gutter proximal to the prestomum area. Lowne (1895) thinks that the real function of these is to approximate the paraphyses while Hewitt (1914) is of the opinion that their contraction widens the channel of the labium-hypopharynx, but the contractions of these in *S. balteatus* seem to increase the cavity of the labial gutter.

MUSCULATURE OF THE THORAX

In accordance with the swift flight of this fly, the thoracic musculature has undergone a great development and modification. With the reduction of the pro-thorax and meta-thorax, their muscles have also nearly disappeared except for the reduced extrinsic muscles of the head, the legs and the halteres. Morphologically, the typical thoracic muscles are represented in the mesothorax where considerable modifications have taken place.

PROTHORACIC MUSCLES

(A) *Extrinsic muscles of the head :*

The head can only be moved in a dorso-ventral plane and the muscles associated with the movement are inserted on the cervical sclerite and take their origin in the prothorax.

(i) *The dorsal longitudinal muscles* (Fig. 4; 18A and 18B) comprise two bundles which arise from the anterior surface of the anterior mesothoracic phragma and become inserted on the post-occipital ridge of the head. Their contraction facilitates the forward and backward movements of the head on the neck.

(ii) *The ventral longitudinal muscle* (19) arising from the sternal apophysis is attached on the tentorial bridge as is usual with the pterygote insects. The contraction of this muscle supplements the effect of the contraction of the dorsal longitudinal muscles.

(B) *Cervical sclerite muscles :*

In addition to the above mentioned sets of direct extrinsic muscles, the head is moved indirectly in a dorsol-ventral plane by two pairs of cervical sclerite muscles which have their origin in the prothorax.

(i) *Dorsal cervical sclerite muscle* (20) originates from the antero-lateral region of the pronotum and following an oblique course gets inserted on the posterior dorsal margin of the lateral cervical sclerite. The contraction of this muscle moves the head downward.

(ii) *Ventral cervical sclerite muscle* (21), the antagonistic of the dorsal cervical muscle, arises from the sternal apophysis and becomes inserted on the ventro-posterior margin of the lateral cervical sclerite. Its contraction is responsible for the upward movement of the head.

(C) *Extrinsic muscles of the fore-leg :*

The extrinsic muscles of the prothoracic leg are represented by the following seven muscles:—

(i) *The tergal promotor* (Fig. 4; 22) of the leg arising dorsally from the anterior side of the pronotum gets inserted below on the anterior end of the procoxa. Its contraction draws the leg forward.

(ii) *The tergal remotor* (23) of the coxa is a stout muscle and arises postero-laterally on the pronotum to become inserted on the posterior angle of the basal rim of the coxa. It moves the leg backward.

(iii) *The pleuro-coxal muscle* (24) arising from the pro-pleural region is inserted on the coxal base on its outer margin. Its contraction supplements the forward movement of the leg.

(iv) *The coxal adductor muscle* (25) arising on the sternal apophysis is inserted on the mesal margin of the coxa. This moves the coxa inwards.

(v) *The sternal promotor* (26) of the leg arising from the prosternum anteriorly is inserted on the anterior part of the coxal base. It serves to move the leg forward.

(vi) *The sternal remotor* (27), is perhaps represented by a set of delicate muscle fibres which become inserted on the posterior part of the coxal base.

(vii) *An extra coxal depressor of trochanter* (Fig. 5; 28) arises dorsally on the pronotum, slightly posterior to the origin of the tergal promotor, passes through the coxal cavity and gets inserted on the base of the trochanter. The contraction of this moves the leg from above downward and inwards.

Pterothoracic Muscles

In Diptera, due to the extensive development of the mesothorax, the metathoracic component of the pterothorax has undergone an extreme reduction. This has consequently resulted in an elaborate development of the musculature in the mesothorax and a loss or degeneration of large number of muscles in the metathorax. Mesothorax, being the chief centre of flight, also contains the major flight muscles whereas the flight muscles of the metathorax are represented by a mere vestige at the base of the haltere.

For the practical convenience the pterothoracic muscles may be broadly classified into two groups namely (A) the indirect flight muscles and (B) the direct flight muscles.

(A) *Indirect flight muscles:*

These comprise (i) six pairs of dorsal longitudinal muscles, (ii) two lateral oblique dorsal muscles, (iii) two tergo-sternal muscles and (iv) two tergal remotors of the coxa.

(i) *Dorsal longitudinal muscles* (Figs. 7 and 11; 29A-29F) consist of six pairs of muscle bundles representing the most powerful muscles of the thorax. These provide the main propelling force in flight and of these the anterior most (29A) arises from the anterior mesothoracic phragma and all the others (29B-29F) arise from the anterior dorso-lateral walls of the mesotergum, extend postero-ventrally to get inserted on the anterior surface of the highly developed posterior mesothoracic phragma. It is interesting to note here that due to the enormous development of the posterior mesothoracic phragma, the direction of the dorsal longitudinal muscles from the longitudinal axis of the body has become changed to almost an oblique position. By the contraction of these muscles the wings are depressed, since the mesotergum is greatly arched upward to deflect the wings on the pleural wing process.

(ii) *Lateral obliques dorsals* (Fig. 11; 30A and 30B) formed by two pairs of strong muscle bundles arise on the posterior part of the mesoscutum and are inserted posteriorly on the posterior mesothoracic phragma mesad to the insertion of the dorsal longitudinal muscles. These are large thick bundles, assuming almost a vertical position due to the great size of the posterior mesothoracic phragma. These are considered here as the depressors of the tergum and act as powerful adjuncts of the tergo-sternal muscles.

(iii) *Tergo-sternal muscles* (Figs. 7 and 11; 31A and 31B) are represented by two pairs of powerful muscle bundles which are attached dorsally on the anterior part of the meso-prescutum, and ventrally on the mesosternum in front of the mid-coxae. These act as antagonistic of the dorsal longitudinals. Their contraction depresses the mesotergum thereby elevating the wings on the pleural wing process which functions as the fulcrum in the movements of the wings.

(iv) *The tergal remotors of the coxae* (32A and 32B) which represented by two pairs of stout muscles, are a characteristic feature of higher Diptera. Normally they function as the tergal remotors of the mid-legs but their insertions have become shifted from the coxa on to the pleural wall due to the imperceptible amalgamation of the coxal meron with the pleural region. This has resulted in the functional change of these muscles, which in this case serve to depress the tergum and furnish an extra help to the tergo-sternal muscle components by elevating the wings.

(*B*) *Direct flight muscles :*

The muscles that are directly attached to the base of the wing and serve to flex or extend the wings include (i) the tergo-pleural muscles, (ii) the muscles of the axillaries and (iii) the muscles of the epipleurites.

(i) *Tergo-pleural muscles* (Fig. 8; 33-36) are distinctly divided into (a) the first tergo-pleural, (b) the second tergo-pleural, (c) the third tergo-pleural and (d) the fourth tergo-pleural muscles.

(a) *The first tergo-pleural muscle* (33) is a short but stout muscle from the anterior part of the prescutum to the basalare. Miller (1950) referred to it as the muscle of the pre-alar apophysis in *Drosophila.*

(b) *The second tergo-pleural muscle* (34) is a rather small but strong bundle of thick muscle fibres, which arises from the mesoscutum near the wing base to become inserted on the wing process. It corresponds to Ritter's (1911) adductors and functions to draw the wing horizontally forward.

(c) *The third tergo-pleural muscle* (35) is a large muscle which arises from the mesoscutum anterior to the pleuro-furcal articulation of the wing and gets attached to the posterior margin of the basalare apodeme. The contraction of this muscle sharply extends the wing in a horizontal plane. Snodgrass (1935) referred to it as the tergo-basalar muscle and reported its occurrence in some Diptera.

(d) *The fourth tergo-pleural muscle* (36) is a long muscle, the fibres of which arise from the posterolateral margin of the scutum, runs antero-ventrally to get inserted on the pleural ridge. This muscle seems to have some influence on the movement of the tergum.

(ii) *The axillary muscles* (37 and 38) include two prominent muscles that arise on the pleuron and get inserted on the first and the third axillary sclerites.

(a) *The first axillary muscle* (37) which is known to occur in Diptera only (Snodgrass, 1935 and Miller, 1950) is divided into two parts. The anterior component arises from the episternum and the posterior from the pleural ridge, both converging to get inserted on the inner margin of the Comma-shaped first axillary. Snodgrass (1935) believes that a pull on this muscle turns the axillary upwards on its tergal articulation which is usual action of the first axillary during flexion of the wings. These correspond to levators of the wing as reported by Ritter (1911).

(b) *The muscle of third axillary* (38) arises on the pro-episternum and gets inserted on the third axillary at its proximal angle. Its contraction revolves the third axillary on its anterior articulation with the first axillary with the result that the posterior margin of the wing is depressed. This muscle corresponds to the flexor of Miller (1950) and first supinator of Ritter (1911), which draws the wing backward towards the body.

(iii) *The epipleural muscles* (39 and 40) include the muscles of the basalare and the subalare.

(a) *The basalare muscle* (39) arises from the antero-dorsal margin of the pro-episternum and gets inserted on the anterior margin of the basalare. Its contraction depresses the anterior margin of the wing. It corresponds to Ritter's (1911) pronator of the wing. Miller (1950) describes an additional basalar muscle in *Drosophila* as *muscle anonymous* of unknown function, which is not observed in *S. balteatus*.

(b) *The subalare muscle* (40) is a rather weak muscle that arises from the epimeral wall. Its contraction serves to depress the wing. Snodgrass (1935), Miller (1950) and Ritter (1911) also have reported single basalare muscle that draws the wing downward and backward towards the body.

Besides these thoracic muscles, there are present the thoracic spiracular closing muscle (Fig. 6; 41), a single muscle of the haltere, the typical ventral muscles and the pleuro-sternal muscles connecting the furcal arms to the free ends of the pleural apophysis.

C. *Intrinsic musculature of the leg:*

The intrinsic musculature of the leg comprises the following seven muscles :—

(i) *The levator of the trochanter* (Fig. 5; 42) after arising dorsally on the outer surface of the coxa runs obliquely downwards to become inserted on the anterior basal rim of the trochanter.

(ii) *An intra-coxal depressor of trochanter* (43) which acts as the antagonistic of the dorsal levator of the trochanter, arises on the outer surface of the coxa and gets inserted laterally on the basal rim of the trochanter.

(iii) *The reductor of femur* (44) is constituted by a large number of fibres from the base of the trochanter and gets inserted on the posterior angle of the proximal femoral rim. Its contraction brings about a rearward flexion of the femur on the trochantero-femoral hinge.

(iv) *An extensor of tibia* (45) is constituted by a large number of fibres from the base and the anterior inner surface of the femur. It runs along the anterior margin to become inserted on the anterior angle of the proximal tibial rim. The contraction of this powerful muscle extends the tibia.

(v) *A flexor of tibia* (46) arises along the posterior surface of the femur and is inserted at the posterior angle of the basal tibial rim. It functions as an antagonistic to the extensor of tibia.

(vi) *The depressor of the pretarsus* (47) arises as a fan-shaped bundle of few fibres in the proximal region of the femur. Midway the femur, it develops into a long tendon, passing through the femur, tibia and the tarsus to finally become inserted on the unguitractor plate. Along its course this tendon receives muscle fibres in the distal region of the femur and the posterior wall of the tibia.

(vii) *A tarsal extensor* (48) arising from the middle of the anterior wall of the tibia is inserted on the base of the metatarsus. Its contraction brings about the straightening of the tarsus.

MUSCULATURE OF THE ABDOMEN

The main musculature of a typical segment of the abdomen comprises the dorsal longitudinal, the ventral longitudinal and the lateral tergosternal muscles. These muscles help in fixing the abdomen on the thorax and in telescoping the segments. In the genitalia the typical segmental muscles have become modified to operate the genital structures. *The dorsal longitudinal muscles* (Fig. 12; 49A) of the first reduced abdominal segment consist of a few muscle fibres which are attached on the intersegmental fold between the first and the second abdominal segments posteriorly and run forward to get attached at a point on the lateral angles of metanotum. Their contraction brings the second abdominal segment near to the thorax. The tergo-sternal muscles are represented by a few fibres which extend from the lateral margin of the first tergum to the lateral border of the first sternum. Their contraction results in the folding of the pleural membrane.

Ventrally the abdomen is attached to the thorax by stout *ventral longitudinal muscles* (Fig. 13; 50A) which arise from the posterior arms of the sternal apophyses of the metathorax and get attached on the first sternite. No spiracular muscles are present in this segment.

The musculature of the second, third, fourth and the fifth abdominal segments presents a typical plan. The lateral half of each tergum is provided with about 25-30 dorsal longitudinal fibres (Figs. 12 and 14; 49B-49E) which arise from the posterior half of the tergum and get inserted on the intersegmental fold separating the segment behind. The dorsal longitudinal fibers in each of these segments are of short size and extend only up to posterior one-fourth of the tergal length. Their contraction helps in the telescoping of the segments. Miller (1950) reports 15-25 dorsal longitudinal fibres in each abdominal segment in *Drosophila.* Ventrally these segments are provided with rather long about 12-15 *ventral longitudinal muscle fibres* (Fig. 13 and 14; 50B-50E) on each lateral half of the sternum. *The lateral tergo-sternal muscles* (Fig. 14, 51-51D) in each of these segments are the most powerful compressors throwing pleural membrane into longitudinal folds. Tergo-sternal fibres vary from 45-50 in the second, the third and the fourth abdominal segments, whereas the number is reduced about 30 fibres in the fifth abdominal segment. Miller (1950) reported about 20 fibres in each abdominal segment. In addition to these typical muscles, the abdominal segments 2-7 are provided with an occlusor muscle (Fig. 15; 52) of the spiracle. The transverse abdominal muscles are represented only by four pairs of alary muscles which have been separately described in the paper on circulatory system and associated tissues. The temporary oblique dorsal muscles described by Miller (1950) are not observed in *S. balteatus.*

Musculature of the genitalia—In the male terminalia, the musculature is very much developed. There are four prominent sets of muscles. A pair of long muscles *the retractor of aedeagus* (Fig. 10; 53) arise from the intersegmental fold between the eighth and the ninth sternites and become attached to the head of the sustentacular apodeme below the base of the phallobase. The powerful contraction of these muscles serve to retract the aedeagus. Another set of very powerful muscles arise laterally from the ninth sternum and get inserted on the shaft of the sustentacular apodeme throughout its length. The contraction of these fibres pushes the apodeme posteriorly thereby thrusting the aedeagus out at the time of copulation. This set may well be considered as *the protractors of the aedeagus* (54). Miller (1950) has also reported prominent retractor and protractor muscles of the aedeagus in *Drosophila.* A distinct *flexor of the style* (Fig. 9; 55) originates on the antero-lateral wall of the ninth tergum and is inserted on the inner angle of the base of the style. The contraction of this brings the styles closer. The strong antagonistic set of muscles to the flexor of the styles, are the modified *tergo-sternal muscles* (56) of the ninth segment. They arise from the dorso-lateral wall of the ninth tergum and run obliquely downwards to become inserted on the lateral borders of the highly modified ninth sternum, that constitutes the roof of the male genital chamber. Singh and Misra (1955) also observed similarly in *Pachydiplosis oryzae* Mani.

Some of the typical muscles of the eighth and succeeding segments are modified and function as the muscles of the female genitalia.

SUMMARY

Thirteen muscles are associated with the proboscis, four of which are extrinsic and nine intrinsic. Each antenna has two intrinsic muscles. Prothoracic muscles include the dorsals, the laterals and the ventrals. The indirect wing muscles include six pairs of dorsal longitudinal bundles, two lateral oblique dorsal muscles, two tergosternal muscles and two tergal remotors of the coxa. Direct wing muscles are those of the axillaries and the epipleurites. Muscles of the coxa and the intrinsic leg muscles are discussed separately. Metathoracic musculature is greatly reduced. Abdominal muscles comprise the dorso-longitudinal, the ventral longitudinal and the lateral muscles. Spiracular and genital muscles are separately mentioned.

ACKNOWLEDGEMENTS

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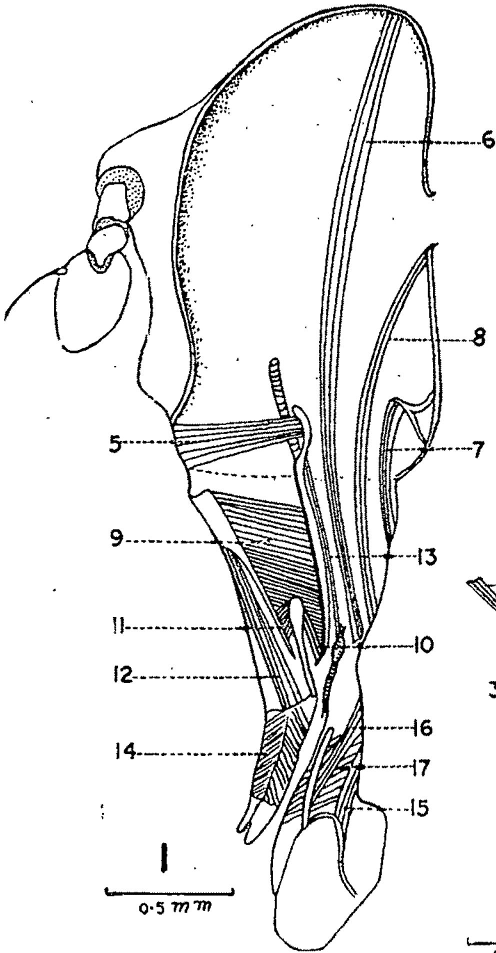
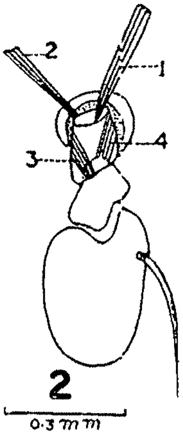




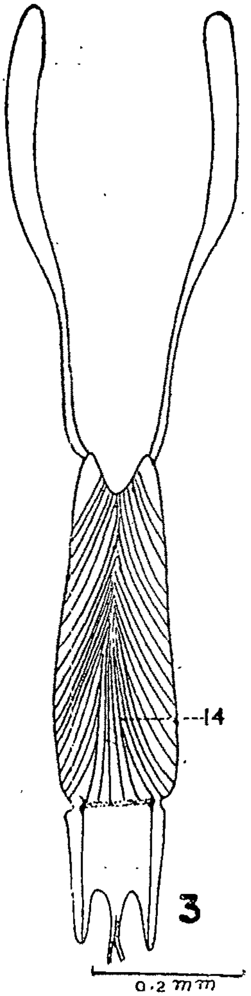


Fig. 1. Musculature of the proboscis.
Fig. 2. Muscles of the antenna.
Fig. 3. Muscles of the labrum-epipharynx (Highly magnified).

1-Antennal depressor; *2*-Antennal levator; *3*-Antennal adductor; *4*-Antennal abductor; *5*-Retractor of the fulcrum; *6*-Retractor of the rostrum; *7*-First accessory retractor of the rostrum, *8*-Second accessory retractor of the rostrum; *9*-Dilators of the pharynx; *10*-Extensor of the haustellum; *11*-Accessory extensors of the haustellum; *12*-Flexor muscles of the labrum; *13*-Regulator of the salivary pump; *14*-Dilators of the labrum-epipharynx; *15*-Retractors of the furca; *16*-Retractors of the paraphysis; *17*-Dilators of the labial gutter.

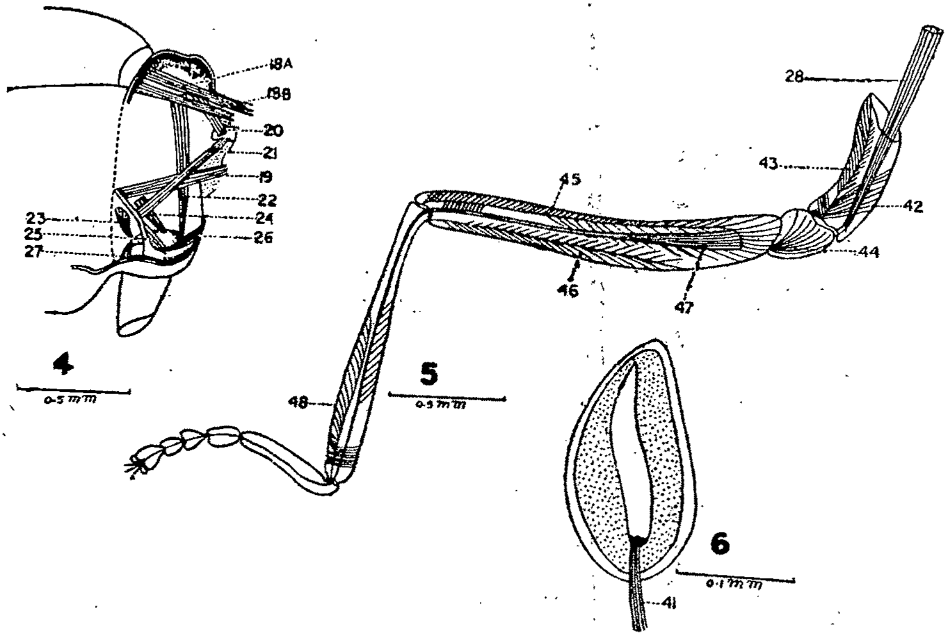
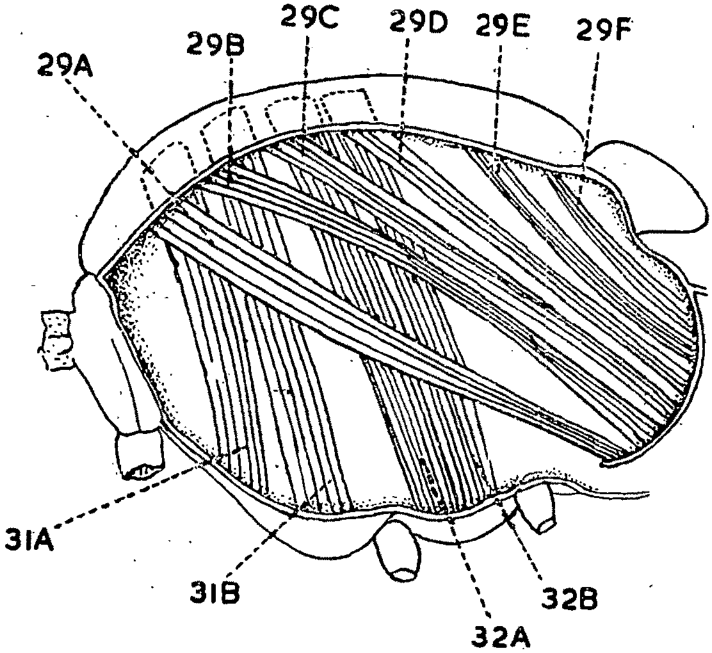


Fig. 4. Prothoracic muscles and extrinsic muscles of the fore-leg.
Fig. 5. Intrinsic leg muscles.
Fig. 6. Anterior thoracic spiracle.

18A&*18B*—Dorsal longitudinal muscles for the prothorax; *19*-Ventral longitudinal muscle of the prothorax; *20*-Dorsal cervical sclerite muscle; *21*-Ventral cervical sclerite muscle; *22*-Tergal promotor of the leg; *23*-Tergal remotor of the coxa; *24*- Pleuro-coxal of the coxa; *25*- Coxal adductor; *26*-Sternal promotor of the leg; *27*-Sternal remotor of the coxa; *28*-Extra coxal depressor of trochanter; *41*-Closing spiracular muscle of the anterior thoracic spiracle; *42*- Levator of trochanter; *43*-Intra coxal depressor of trochanter; *44*-Reductor of femur; *45*-Extensor of tibia; *46*-Flexer of tibia; *47*-Depressor of pretarsus; *48*-Tarsal extensor.



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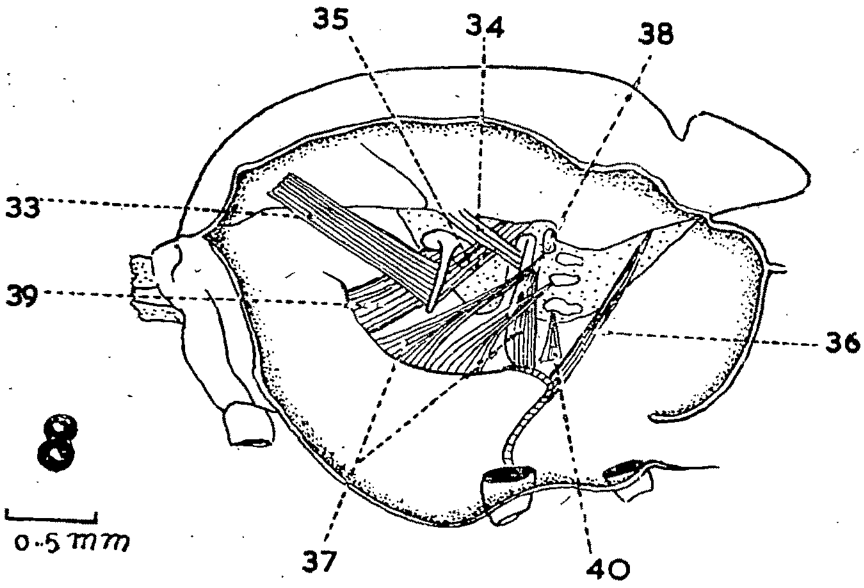

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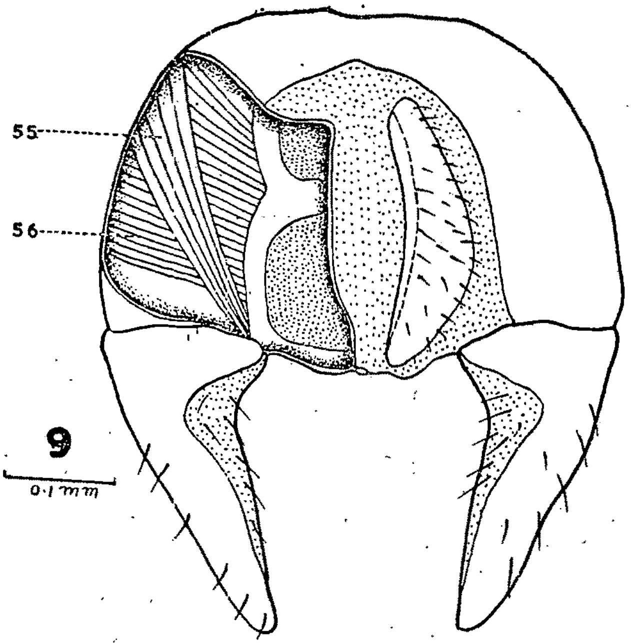
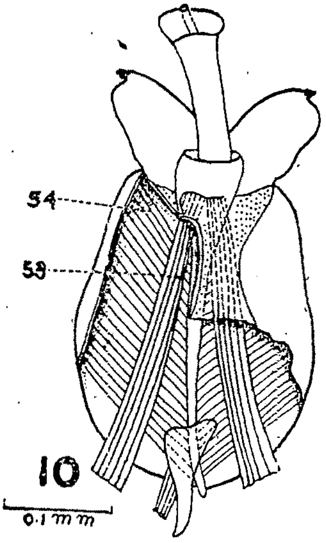
Fig. 7. Lateral view of the thorax cut open to show the indirect flight muscles.
Fig. 8. Lateral view of the thorax cut open to show the direct flight muscles.

29A—29F-Dorsal longitudinal muscles of the mesothorax; *31A*&*31*B-Tergo-sternal muscles of the mesothorax; *32A*&*32*B-Tergal remotors of the coxae; *33* First tergo-Pleural muscle; *34*-Second tergo-pleural muscle; *35*-Third tergo-pleural muscle;*36*-Fourth tergo-pleural muscle;*37*-First axillary muscle;*38*-Muscle of the third axillary sclerite; *39* Basalar muscle; *40*-Subalar muscle.





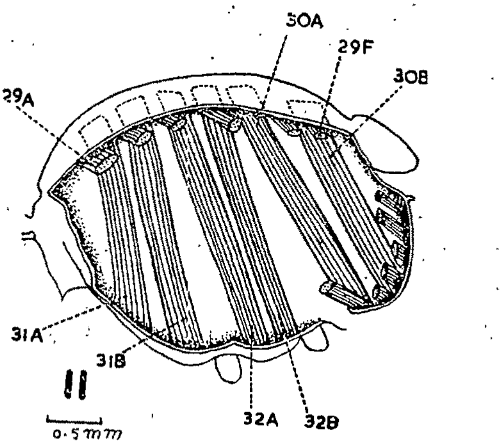
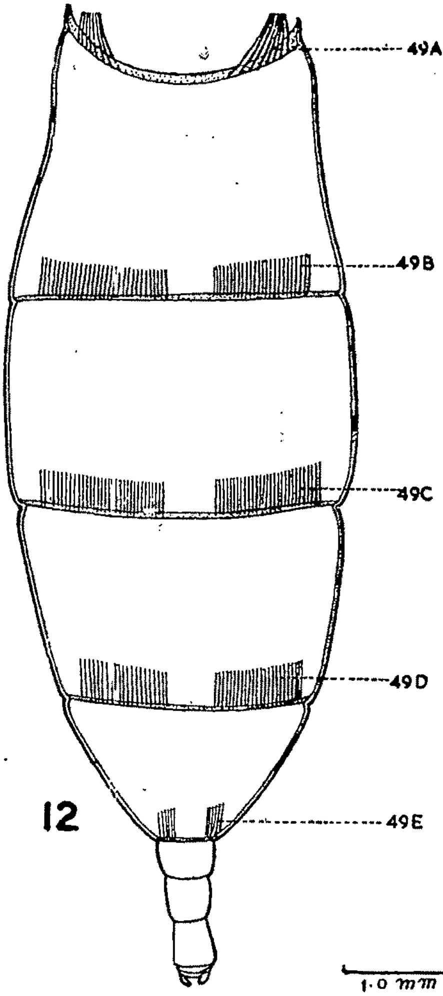


Fig. 9. Lateral view of the thorax cut open to show the tergo-sternal and lateral oblique muscles of the mesothorax

Fig. 10. Dorsal view of the genitalia to show the muscles of the style.

Fig. 11. Muscles of the aedeagus.

29A-29F-Dorsal longitudinal muscles of the mesothorax; *30A&30*B-Lateral oblique dorsal muscles of the mesothorax; *31A&31*B-Tergo-sternal muscles of the mesothorax; *32A&32*B-Tergal remotors of the coxae; *53*-Retractor of the aedeagus; *54*-Protractor of the aedeagus; *55*-Flexor of the style; *56*-Tergosternal muscles of the ninth abdominal segment.



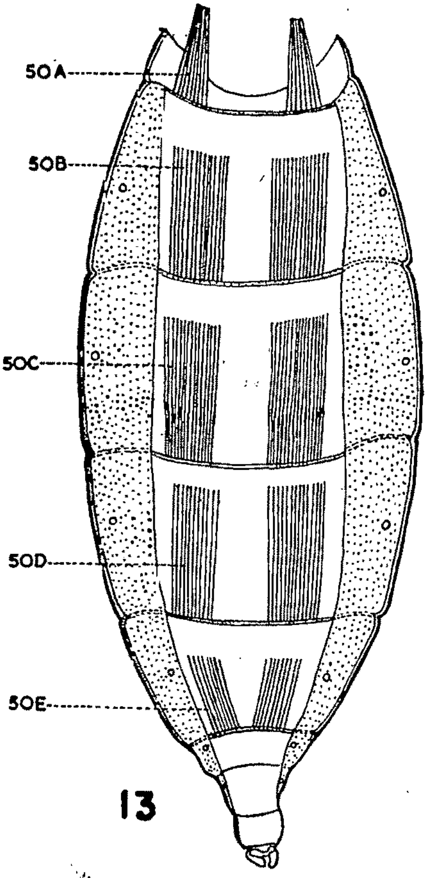
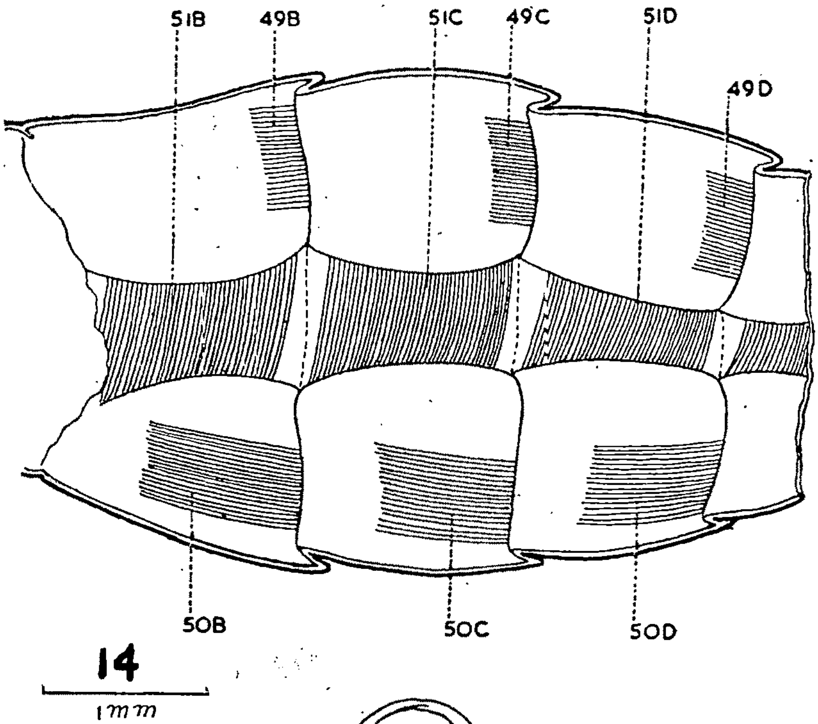


Fig. 12. Abdomen showing dorsal longitudinal muscles.
Fig. 13. Abdomen showing ventral longitudinal muscles.
49A-49E-Dorsal longitudinal muscles of the first to the fifth abdominal segments-*50A-50E*-Ventral longitudinal muscles of the first to the fifth abdominal segments.



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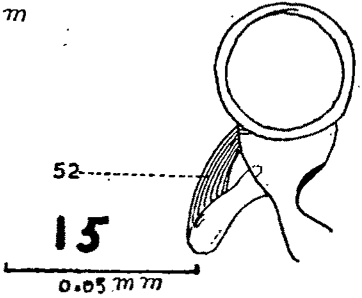

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Fig. 14. Lateral view of the abdomen showing the dorso-longitudinals, veteral-longitudinals and tergo-sternal muscles (Schematic)
Fig. 15. Abdominal spiracle.

49B-49D-Dorsal longitudinal muscles of the second to the fourth abdominal segments; 50B-50D Ventral longitudinal muscles of the second to the fourth abdominal segments: 51B -51D-Tergo-sternal muscles of the second to the fourth abdominal segments; 52-Occlusor muscle of the abdominal spiracle

PART III. VERTEBRAL COLUMN OF *NANDUS NANDUS* (HAM.)

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Introduction

The Part III deals with the vertebral column of *Nandus nandus* (Ham.). The Parts I and II included its skull and the appendicular skeleton.

From a perusal of literature, it is evident that very little work has been done on the vertebral column. The vertebral column along with the complete endoskeleton has been described by Johnson (1918) in *Ramphocottus richerdsoni*, Sarbahi (1932) in *Labeo rohita*; Dharamranjan (1936) in *Otolithus rubber*, Lele and Kulkarni (1938) in *Perioptha lmus barbanus*; Nawar (1954) in *Clarias lazera* and Karandikar and Thakur (1954) in *Sciaenoides brunneus*. Mookerjee, Ganguly and Mookerjee (1952) gave an account of the vertebral column and the weberian ossicles of *Esomus danricus*.

Observation

The vertebral column of *Nandus nandus* consists of 23 vertebrae; the trunk region has 13 and the caudal region 10 vertebrae. All the vertebrae, except the last, are amphicoelous and are immovably attached to one another. The intervertebral space between the adjoining biconcave centra is filled with the remanents of the notochordal tissue.

Typical trunk vertebra (Fig. 20)—A typical trunk vertebra has a deeply biconcave cylindrical centrum (cen), being perforated by a narrow notochordal canal. From the dorsolateral ridges of the centrum, arise, the neural arches (nar). A long backwardly tapering neural spine (ns) arises from the junction of the neural arches. The anterior and posterior margins of the neural arches are produced into short processes, the prezygapophyses (prz) and postzygapophyses (poz) respectively. Laterally the wall of each side of the neural arch is perforated by a pair of small apertures (ap) for the exit of the paired roots of the spinal nerves. Ventro-laterally, the centrum gives off a pair of stout processes, the basapophyses or parapophyses (bap) which carry the pleural ribs (plr). The ventral surface of the centrum bears a shallow groove; it has a small aperture, opening into the centre of the centrum.

The typical structure of a number of trunk vertebra shows individual variations. A brief account of such vertebrae is, therefore, described with special referencc to their peculiar features.

First vertebra (Fig. 16. A, B, C)—Unlike the typical vertebra, the neura arch of the first vertebra is movably planted into dorsally situated pits of the centrum. There is a single aperture (ap) on the neural arch for the spinal nerve. The anterodorsal margin of the centrum is modified into a pair of flat oval articulatory facets (af) which in situ are fitted on to those of the exoccipital. The pleural rib is attached to the marginal groove (g) of the neural arch of each side. The basapophyses are absent.

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Second to fifth vertebrae (Figs. 17, 18)—They resemble to a great extent with the typical vertebra. However, the neural spine is long while the postzygapophyses are reduced to very short processes. There is only a single aperture for the nerve. The grooves (gr) to which the pleural ribs are attached, are deep. There is no indication of basapophyses in any of these vertebrae.

Sixth and Seventh vertebrae (Fig. 19 A, B)—The neural arches with their spine, are greatly inclined backwards. The postzygapophyses are in the form of simple grooves. Antero-laterally, the 6th vertebra shows small processes (bap) which in seventh vertebra shifts more on the ventral side. These processes in the succeeding vertebrae form the basapophyses. The pleural ribs arise from the base of these processes.

Eighth to twelth vertebrae (Figs. 20 & 21)—These vertebrae are generally similar to the typical vertebra. However, the basapophyses are better developed. In eighth vertebra, the grooves of the neural arches are lost and new grooves are formed on the bases of the basapophyses. The basapophyses gradually shift towards the ventral side of the vertebrae.

Thirteenth vertebra (Fig. 22 A, B)—This last trunk vertebra is somewhat different from the preceding trunk vertebrae. The neural arch and its spine are thin; the latter is largest of all the trunk vertebrae. The diverging basapophyses join each other postero-laterally, thus forming a definitive haemal arch (he) continued distally into a slender posteriorly directed haemal spine (hs). This vertebra, inspite of the presence of haemal spine, is included in the trunk region because of the presence of a pleural rib attached along the sides of the haemal arches.

Typical Caudal vertebrae (Figs. 23 to 25)—The caudal region consists of 10 vertebrae which have generally a uniform structure except the last two. Typically a caudal vertebra is to a great extent similar to the last trunk vertebra, except that the haemal spines (hs) are larger and stouter. The haemal spines of the first four vertebrae are of equal size but gradually decrease towards the posterior end. The neural spines (ns) of the first two vertebrae are larger than the spines of the remaining caudal vertebrae. The neural arch of 14-21 vertebrae carry double exit on each side for the spinal nerves. In all the caudal vertebrae the pre- and post-zygapophyses are reduced to very small processes. The centrum of the first four caudal vertebrae are of equal size while it gradually decrease in the following vertebrae. There is a shallow median groove on the ventral surface of the centrum.

Twenty second vertebrae (Fig. 24)—The neural spine, which forms the epural (epu), becomes slender and larger in size and extends upto the caudal fin rays. Ventrally the haemal arch (ha) and its spine (hs) are extensive and slightly flattened. The bifurcated haemal spine hp) extends posteriorly up to the base of the caudal fin. The haemal spine may be called as hypural (hp) bone, because according to Goodrich (1930) it is a product of fusen with the ventral radial.

Twentythird vertebra—The last caudal vertebra is specialized for the support of the caudal fin. It is produced behind into an upturn rod-like process, the urostyle (ur) which probably represents, several fused centra of the posterior region. The three dorsal hypurals (hp) are attached on the ventral surface of the centrum of the last vertebra. According to Goodrich (1930), the hypural is typically formed by the fusion of a fin radial with the spine of a haemal arch. If this be true, the ventral most hypural would belong to the last caudal centrum with which it articulates, while the remaining six hypurals would represent the haemal spine of the centra, fused to form the urostyle. Thus urostyle would represent six fused centra. The neural spine of the last caudal vertebra is attached to the dorsal most hypural. There is a separate radial (rad) lying dorsal to the neural spine.

Ribs. (Figs. 26, 28)—There are two kinds of ribs in *Nandus*, the ventral and the dorsal. The first thirteen vertebrae carry a pair of ventral or pleural ribs (pl). The points of attachment of the pleural ribs to the vertebrae show a great variation. It has been found to shift from its dorsolateral position to the ventral. In the first and second vertebrae the ribs are inserted dorsolaterally into the grooves of the neural arches. In 3rd to 5th vertebrae, they are planted in prominent sockets borne laterally by the centrum. In vertebrae 6th to 8th, they are fixed ventrolaterally in small pits on the centrum at the base of basapophyses. From 9th onwards upto 12th vertebrae the ribs have no connection with the centrum but are attached to the basapophyses along their posterior surface.

The dorsal ribs or epipleurals (plr) lie in the horizontal septum and are attached to the pleural ribs. They are attached to all the pleural ribs except the first two which are without them. The dorsal ribs increase in length anteriorly.

All the free vertebrae of the trunk and caudal regions are normally articulated with one another by intervertebral ligaments and pre- and post-zygapophyses. Anteriorly, from each side of the dorsal aspect of a vertebra, a small, blunt pre-zygapophyses continuous with the base of the neural arch which is projected upwards and forwards and articulates with the upwardly and backwardly directed post-zygapophyses of the preceding vertebra.

DISCUSSION

According to Regan (1913), the number of vertebrae in *Nandus* is 23 (13 + 10) and the parapophyses starts from the 7th or 8th vertebra. The persent observations confirm Regans findings.

Sarbahi (1932), Dharam ranjan (1936), Nawar (1954) and many others have used the term parapophyses for the lateral processes of vertebrae which in the caudal region meet to join haemal arches. Karandikar and Thakur (1954) preferred the term basapophyses rather than parapophyses because of the ventrolateral position. According to Hymen (1945), these processes represent the basapophyses and are homologous with the rudiments of haemal arches which are well developed in the caudal region. The authors of this paper are of the opinion that both the terms can be used for these processes because in the precaudal vertebrae of *Nandus* they arise dorsolaterally and gradually shift in the posterior vertebrae, towards the ventrolateral position so as to form finally the haemal arches. Gadow (1933) writes "The parapophyses are in fact the direct response of that part of the vertebra which the capitulum of the rib needs for its support. In *Nandus* all these processes carry the pleural ribs at their bases.

Goodrich (1930) opines that a specialized caudal fin is characterised by a shortened notochord, completely enclosed within the urostyle which is reduced to a mere vestige and the number of hypurals exceeding that of epurals. Further he states that the hypural is typically formed by the fusion of a fin radial with the spine of a haemal arch. Whitehouse (1910) holds the view that both the epurals and the hypurals are formed due to the fusion of arched elements and their respective spines and radials. In *Nandus* the small urostyle is formed by the fusion of six centra because of the presence of six hypurals attached to it. A separate radial has also been observed in the caudal vertebra of *Nandus*.

SUMMARY

1. The number of vertebrae in *Nandus nandus* is twentythree, thirteen being precaudal and ten caudal vertebrae.
2. The basapophyses emerge from 7th precaudal vertebra.
3. The basapophyses of the anterior vertebrae are dorso-lateral in position while in posterior vertebrae they gradually shift to ventrolateral side and finally meet with each other of the two sides to form the haemal spines.
4. There are two types of ribs, the ventral or pleurals ribs, attached to either the grooves of the neural arches in anterior vertebrae or to the basapophyses in the posterior vertebrae; and the dorsal ribs or epipleurals, attached to the pleurals, in the horizontal septum. Only the precaudal vertebrae carry these ribs. However, the first two precaudal vertebrae are without epipleurals.
5. The last caudal vertebrae is formed by the fusion of six centrum which is shown by the presence of six hypurals attached to the urostyle.
6. There is a separate radial, situated on the dorsal side of the hypurals.

ACKNOWLEDGEMENT

The authors are grateful to Dr. V. P. Agrawal, Head of the Zoology Department, D. A. V College, Muzaffarnagar for his kind suggestions.

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ABBREVIATIONS

af	articulatory facet
ap	aperture
bap	basapophyses
cen	centrum
epu	epural
g	groove
gr	shallow ventral groove
ha	haemal arch
hc	haemal canal
hp	hypural
hs	haemal spine
nar	neural arch
ns	neural spine
pl	pleural rib
plr	epipleural
prz	pre-zygapophyses
poz	post-zygapophyses
rad	radial
ur	urostyle

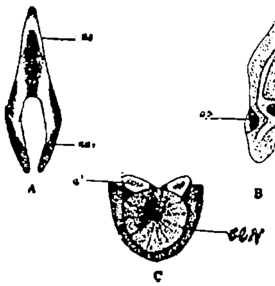


Fig 16

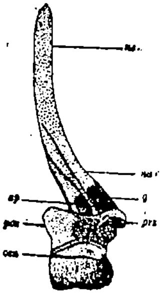
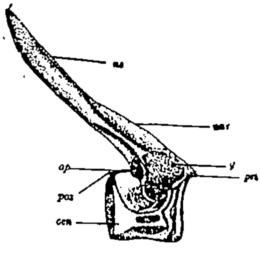


Fig 17



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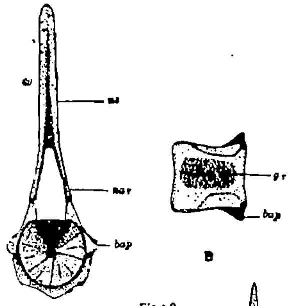

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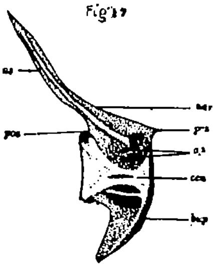

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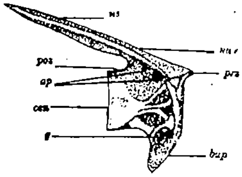

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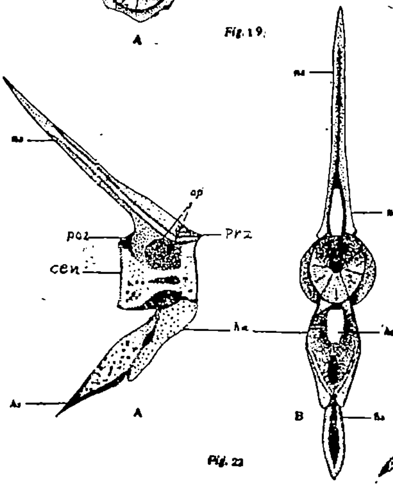

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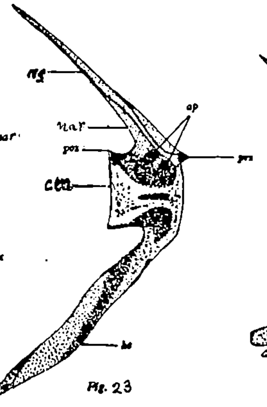

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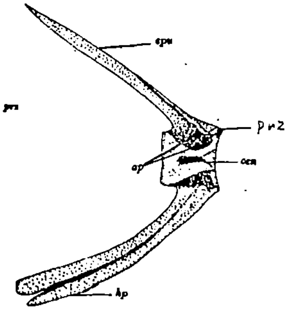

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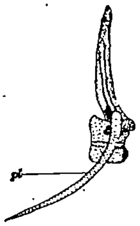
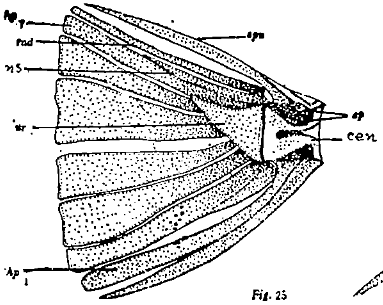


Fig. 26.



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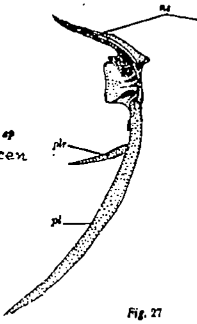

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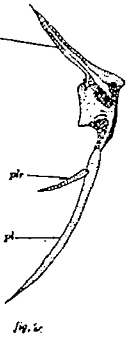

fig. 28

INTERESTING HISTOLOGICAL FEATURES IN THE FORE BRAIN OF *LABEO DERO* (HAMILTON).

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INTRODUCTION

Doon valley is rich with a special hill-stream fish-fauna which provides an ample scope for the correlation of various morphological and histological features with their modes of life. One such problem is the modifications of the brains of fishes with reference to their modes of life.

The present author has worked out the morphology and histology of about half a dozen Cyprinoid fishes of Doon valley. The histology of the brain of *Labeo dero* has, however, been studied in detail and the present account deals with a couple of important features of cerebral hemispheres.

HISTORICAL RESUME

In India, except the works of Bhimachar (1935-1945) and Mookerjee and others (1948-1950), little attention has been paid to this important aspect of fish morphology. Histological studies of the brains of fishes remain completely ignored. Mookerjee and others (1948) have tried to work out the histology of medulla oblongata which is incomplete and based upon its morphology.

MATERIAL AND TECHNIQUE

The cranium of the freshly captured fish was carefully cut open and the brain was dessected out. The material was fixed in different fixatives, chiefly Bouin's, alcohol acetic acid and Da Fano's fluids. Silver impregnation methods were of immense help. After usual procedure the longitudinal and transverse sections of the brain of *Labeo dero* were cut at 6-8 micra. Staining was carried out with different stains such as Haematoxylin, Eosin, etc.

HISTOLOGICAL FEATURES

The most important feature noticed in connection with the cerebral hemispheres is that the lateral ventricles (cavities of cerebral hemispheres), which are typical of Teleost fishes and all other vertebrates, are not present in *Labeo dero* (Figs. 1 and 2).

In *Labeo dero* the telencephalon consists of two solid bodies (Fig. 1) separated from each other only by a slit-like cavity. It is provided with a number of small hair-like outgrowths on the inner and lateral walls (Fig. 3). These hairy outgrowths are borne by the outermost layer of the cells of cerebral cortex which is termed as the plexiform layer. The whole structure is covered by a thin membrane similar to the ependymal layer which represents the streched roof of the telencephalon. A similar condition of the cerebral hemispheres has also been observed in certain other Cyprinoid fishes by the author.

This fact was brought to light at the close of the nineteenth century by Gage (1893) and Studnicka (1896). The same has been recently elaborated by Nicuwenhuys (1960, '62 and '63).

Nieuwenhuys (1962 and 1963), in an account of the comparative anatomy of the Actinopterygian fore-brain, showed the absence of the lateral ventricles. According to him in Teleosts the evagination of the cerebral hemisphere is accompanied by a marked eversion of the dorsal part of the lateral walls which grow downwards and become combined with the ventral part of this wall to form a massive collection of the nervous tissue. Due to this eversion, the lateral ventricles of the cerebral hemispheres are obliterated and it results in the formation of a slit-like median ventricle in between the two solid bodies of cerebral hemispheres.

The observations of the present author in *Labea dero* are in line with the views of Nieuwenhuys (1962 and 1963) but the occurrence of hair-like outgrowths in the slit-like median ventricle of the cerebral hemispheres is rather peculiar and so far it has not been reported for any fish. However, to assign the function of such hair-like outgrowths is rather difficult at this stage and requires further investigations.

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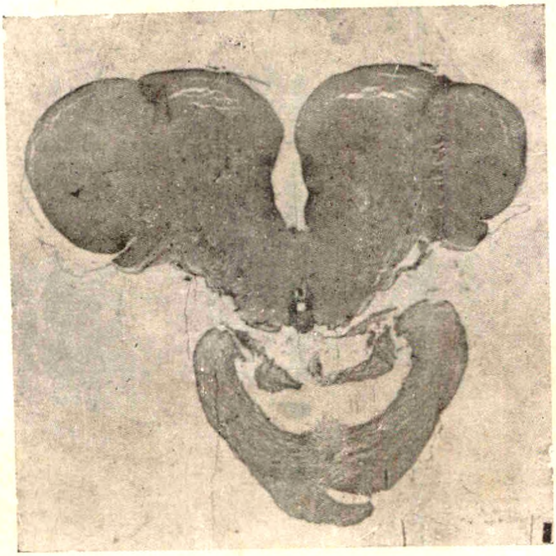

Fig. 1

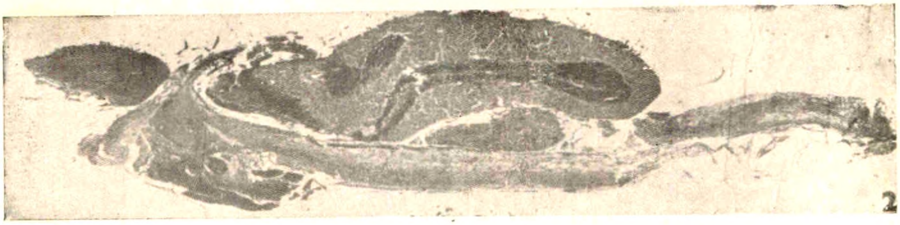

Fig. 2

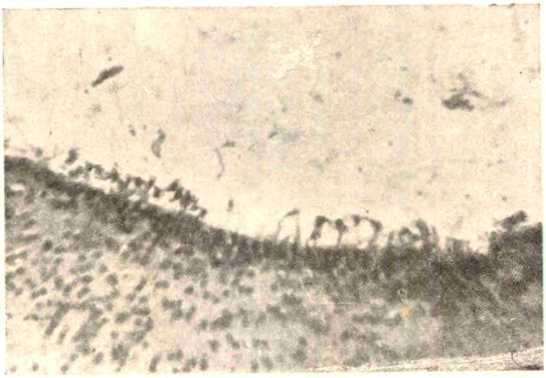

Fig. 3

Text figures (Microphoto)

Fig. 1. Transverse section of the brain passing through cerebral hemispheres.

Fig. 2. Longitudinal section of brain.

Fig. 3. A part of the wall of cerebral cortex highly magnified to show the presence of hair-like outgrowths.

COLLOID-ELECTROLYTE BOUNDARY AND KOHLRAUSCH'S RELATION TA/CA=TB/CB FOR IONIC BOUNDARIES—PART IV

(ELECTROPHORESIS OF As_2 S_3 Sol)

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Srinagar, Kashmir.

SUMMARY

The electrophoretic velocity of As_2 S_3 Sol has been measured using various concentrations of the supernatant liquid acetic acid. The results confirm our earlier conclusions that the analogy between a colloid-electrolyte boundary and a purely ionic boundary is a function of the concentration of the supernatant liquid.

INTRODUCTION

According to the Theory of Moving boundaries as put forth by Kohlrausch (1897), the relation TA/CA=TB/CB (TA & TB being Transport numbers and CA & CB the respective concentrations of the ions (A & B) should be satisfied when the faster (leading) ions A are followed by Slower (indicator) ions B forming a sharp boundary. The concentration of the indicator ion, as the theory visualises, should adjust itself so as to satisfy the above relation. Longsworth (1932) studied this concentration adjustment for ionic boundaries and found that such an adjustment is mostly favoured when the concentrations of the leading and the indicator ions are close to start with.

With colloid-electrolyte boundary, on gradually increasing the concentration of the supernatant liquid it has been observed (Parts I, II, & III of this series) with both positive and negative sol boundaries [Fe $(OH)_3$ Cr $(OH)_3$ and Sb_2 S_3 Sols] that their behaviour is analogous to the ionic boundaries till the concentration of the supernatant liquid is such that its conductivity is less than or equal to that of the sol. With higher concentrations of the supernatant liquid, it is observed that the values of electrophoretic velocities are higher for the positive sols of $Fe(OH)_3$ and $Cr(OH)_3$ and lower for the negative sol of Sb_2 S_3. In the present paper, the effect of concentration of the supernatant liquid on the electrophoretic behaviour of As_2 S_3 sol-acetic acid boundary has been discussed.

EXPERIMENTAL

(a) Preparation of As_2 S_3 sol—The sol was obtained by passing purified H_2S gas slowly through 200 cc of distilled water in which saturated solution of As_2 O_3 was added drop by drop. Excess H_2S was expelled by a slow current of purified Hydrogen. The sol was dialysed against running distilled water.

(b) The apparatus, technique used, and the calculations for the potential gradient under which the boundary is supposed to move (by Kruyt 1928), were same as in Parts I, II, & III of this series.

OBSERVATION AND DISCUSSION

The ascending and descending boundaries of the As_2S_3 sol when various concentrations of the supernatant liquid were used have been shown in Plate nos. 1, 2 & 3. The choice of the supernatant liquid has been discussed in our earlier communications dealing with sharpness of the colloid electrolyte boundaries, and in the light of the conclusions of Mukherjee (1928) and Henry and Brittain, (1933) acetic acid was found to be a suitable supernatant liquid. Considering the ascending boundary we find that the thickness and the colour intensity of advancing sol column which is faint yellow with acetic acid solutions of concentrations lower than the equiconducting concentration (Plate No. 1), changes to yellow and finally to deeper yellow when the concentration of supernatant liquid is such that it is equiconducting and more than equiconducting respectively, (Plates 2 and 3). The behaviour of this boundary qualitatively affirms the analogy between the ionic and colloid boundaries and the changes of the colour of the advancing sol column can be attributed to the concentration adjustment of the indicator ions when they move with the velocity of leading ion (CH_3COO) according to Kohlrausch's relation $T_A/C_A = T_B/C_B$.

The descending boundary remains sharp and unchanged in colour for smaller concentrations of the supernatant liquids used (Plate 1). With equiconducting concentration of acetic acid the sol column appears to get thicker but the boundary remains sharp (Plate 2). But when the concentrations of the supernatant liquid was greater than the equiconducting one, the sol column appears to split up into two regions of lower and higher concentrations and the boundary gets distorted (Plate 3). This observation, (and also similar one pointed out in Part III of this series) may partly be due to the fact that in this case the 'adjusted' concentration of acetate ions that follows the leading sol particles according to Kohlrausch is lower than the concentration of the bulk of supernatant solution. Thus an unavoidable mixing, resulting from a less dencer layer being formed below that of greater density, may lead to a distortion in shape and change in the colour intensity of the descending boundary. Similar effects observed for ionic boundaries have been discussed by Longsworth (1932)

The changes in the electrophoretic velocity (Table 1) observed with the different concentrations of the supernatant liquid show similarity with those observed for Sb_2S_3 sol. In contrast to the positive sols of Fe to Cr hydroxides; the electrophoretic velocity of both As_2S_3 and Sb_2S_3 Sols is lower with supernatant liquids of higher concentrations which gradually increases till equiconducting concentrations and then remains fairly constant with supernatant liquids of lower concentrations as shown in Fig. 1 where the different values of the electrophoretic velocity obtained with various conductivities of the supernatant liquid (*viz.*, equi, half, two or three times conducting solutions represented by C, ½C, 2C or 3C etc.) are plotted.

TABLE 1

As_2S_3 Sol : Descending boundary

Concentration of the supernatant liquid (Acetic acid.)	5C	2C	C	1/2C	1/4C
Electrophoretic velocity Cms/Sec/unit Pot. grad. ($X10^{-5}$)	13.7	33	39.9	41	39.6
ζ-potential volts ($X10^{-3}$)	16	39	47	48	47

It can thus be concluded from the observations of this series of papers, that :—

(1) A part from few discripencies, likely to be due to colloid-electrolyte interactions under the influence of electrifield, Kohlrausch relation $T_A/C_A = T_B/C_B$ holds good for colloid-electrolyte boundaries as far as qualitative considerations are concerned.

(2) The electrophoretic velocity of Sols calculated from Kruyt's assumption changes appreciably when the concentration of the supernatant liquid is such that its conductivity is greater than that of the sol, but with supernatant liquids of equiconducting and lesser concentrations, the electrophoretic velocity is unaltered. Thus the range of the concentration of the supernatant liquids that can be used in electrophoretic investigations is wider than that for ionic boundaries (Longsworth 1932).

Work in this direction so as to throw some more light on the migration of colloid electrolyte boundaries with supernatant liquids of higher concentrations is in progress.

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Variation of Electrophoretic Velocity with various conductivities of the supernatant liquid.

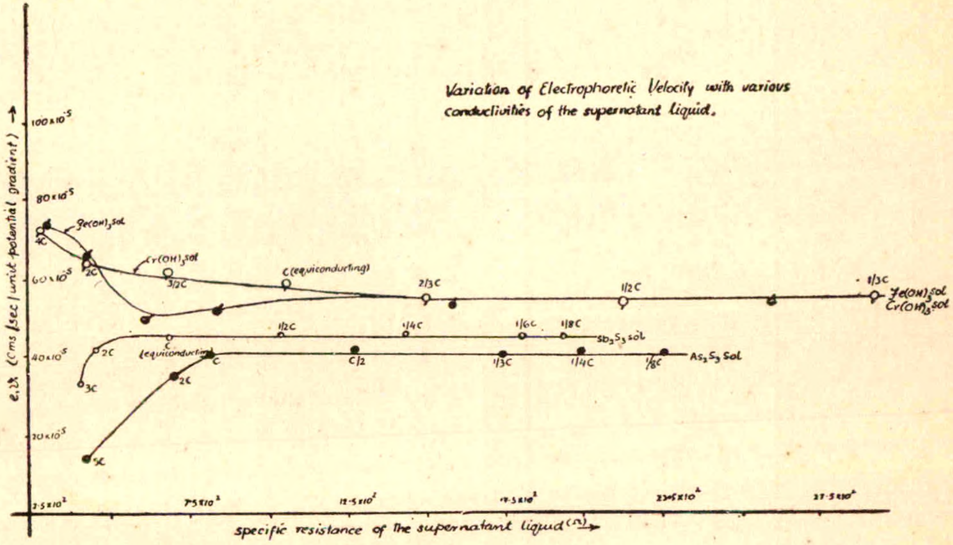

Fig. 1.

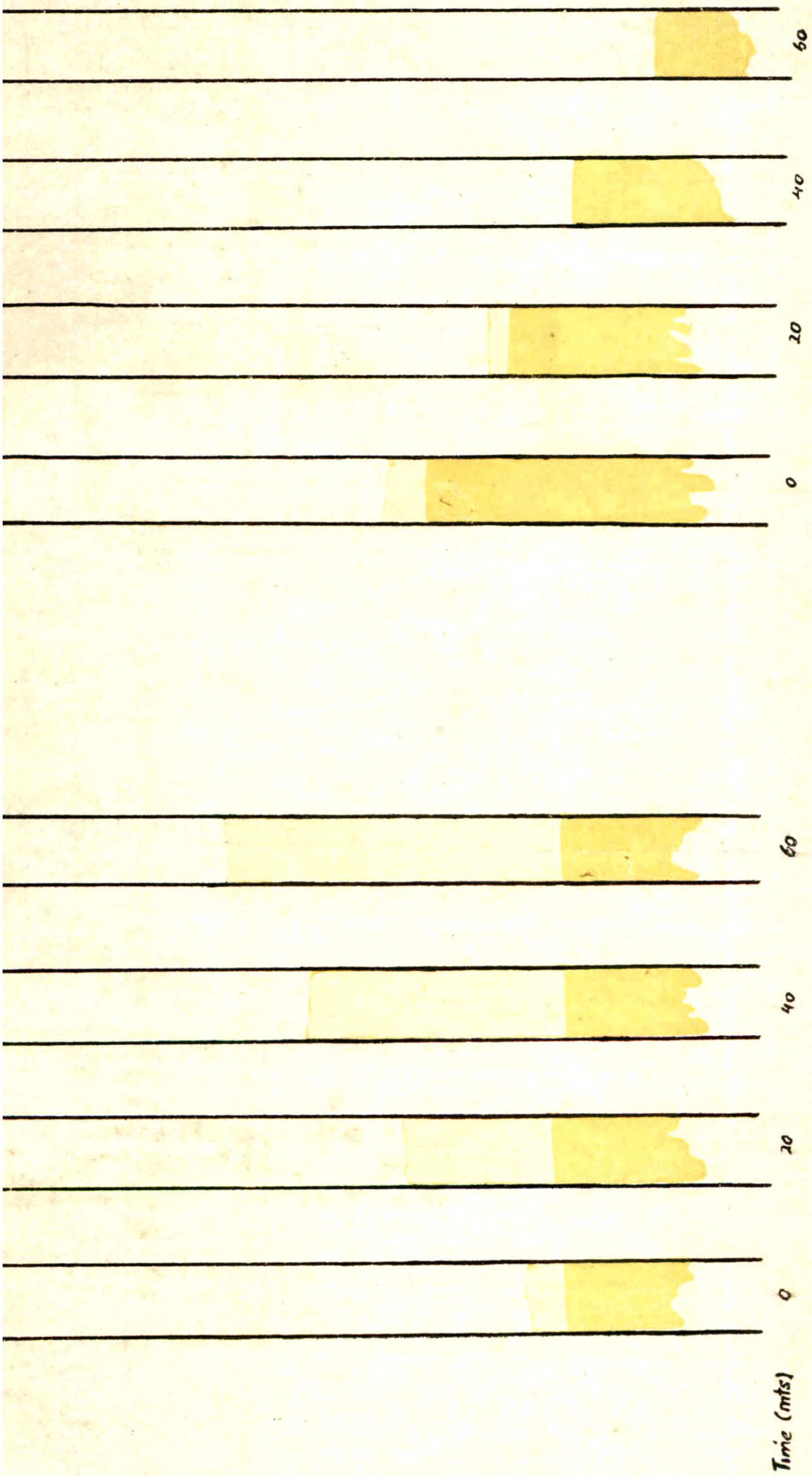

Plate no. 1.

As_2S_3 Sol : Acetic acid solution of concentration lower than the equiconducting.

(Similar results with 1/2 + 1/4 times conducting acetic acid)

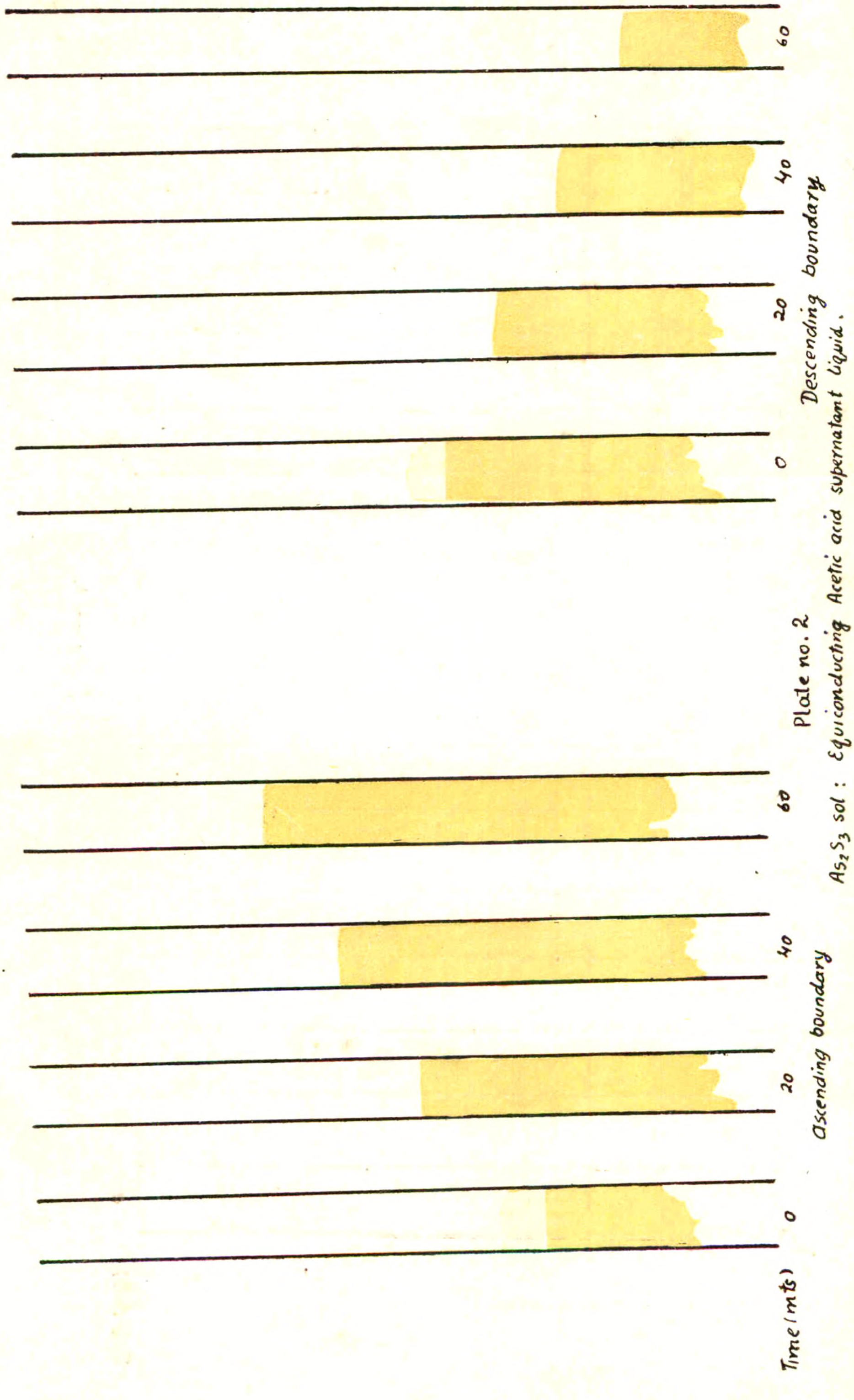

Plate no. 2

As_2S_3 sol : Equiconducting Acetic acid supernatant liquid.

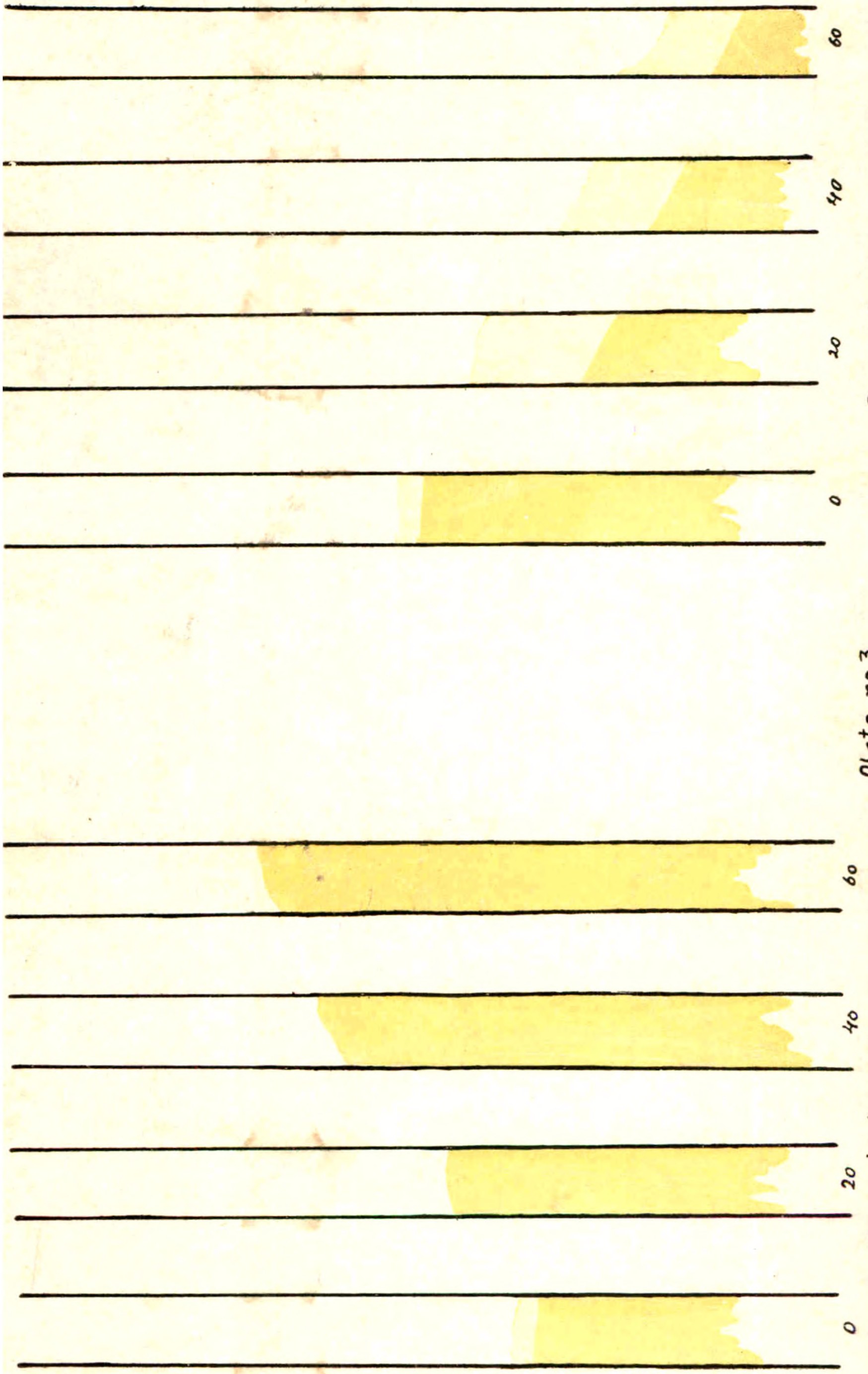

Plate no 3.

As_2S_3 sol : Acetic Acid solution of concentration greater than the equiconducting,
(Similar results with 2 and 3 times conducting acetic acid)

ANTIFUNGAL ACTIVITY OF A *STREPTOMYCES* SP.

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INTRODUCTION

The group actinomycete has been in recent years the focus of great attention by investigators. This increased attention is primarily due to the fact that the actinomycetes comprise many forms that have the capacity to produce a large number of antibiotic substances capable of inhibiting the growth of other microorganisms (Tims 1932, Alexopoulos 1941, Meredith 1944, Cooper and Chilton 1949, Sclegel and Rawlins 1954, Mukherjee and Nandi 1955, Stevenson 1956).

This paper deals with the isolation of a *Streptomyces* sp. antagonistic to *Colletotrichum capsici* (Syd.) Butler and Bisby and a few other fungi, and the effect of various nutrient media on the growth of the organism and the production of the antifungal substance.

EXPERIMENTAL

(i) *Study of Antagonistic Activity :*

A large number of subsurface soil samples were collected from different localities and were plated out for the isolation of actinomycetes on Thornton's medium (Allen 1951) adopting dilution plate technique (Waksman 1927). The plates were incubated at room temperature (25°-28° C) for a week. The colonies developed were picked up on the basis of their pigment differences and other morphological characters and further purified. During screening of actinomycete isolates, a *Streptomyces* sp. (Isolate No. 21) was found to be antagonistic to *Colletotrichum capsici* (Plate 1) and a few other fungi (table, 1).

TABLE 1

Showing the antagonistic activity of Streptomyces sp. (Isolate No. 21)

Organism tested	Inhibition zone in mm.
Rhizopus arrhizus Fischer	nil
Mucor hiemalis Wehmer	nil
Cunninghamella echinulata Thaxt.	nil
Thielavia terricola (Gilman & Abbott) Emmons	nil
Chaetomium globosum Kunze	nil

(*Continued*)

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* Junior Research Fellow, C.S.I.R.

TABLE 1 (*Contd.*)

Showing the antagonistic activity of Streptomyces sp. (Isolate No. 21)

Organism tested	Inhibition zone in mm.
Neocosmospora vasinfecta E.F. Smith	nil
Phoma sp	6
Diplodia cajani Raychaudhury	8
Pestalotia sp.	10
Colletotrichum capsici (Syd.) Butler & Bisby	6
Oospora sp.	6
Trichoderma lignorum (Tode) Harz	4
Aspergillus niger van Tieghem	nil
A. nidulans (Eid.) Wint.	nil
A. terreus Thom	nil
A. flavus Link	nil
A. candidus Link	nil
A. sydowi (Bainier & Sartory) Thom & Church	nil
A. glaucus group	8
Penicillium oxalicum Thom	9
P. funiculosum Thom	nil
P. wortmannii Klocker	3
Thielaviopsis sp.	3
Spicaria divaricata (Thom) Gilman & Abbott	10
Stachybotrys atra Corda	nil
Curvularia verruculosa Tondon and Bilgrami	12
Helminthosporium sativum King & Bakke	8
Alternaria tenuis Nees ex Pers.	11
Fusarium orthoceras App. & Wr.	nil
Macrophomina phaseoli (maubl.) Ashby	6

(ii) *Study on the Effect of Different Nutrient Media:*

The composition of the medium greatly affects the growth and metabolic activity of microorganisms and consequently the production of antifungal substances. In the present study the *Streptomyces* sp. was cultured on seven different broths *viz.*, sucrose nitrate, glucose asparagin, glycerol asparagin, starch solution, glucose peptone A, glucose peptone B and yeast extract.

30 ml. of each medium was taken in 250 ml. Erlenmeyer flasks and autoclaved at 10 lbs. pressure for 30 minutes after which media were inoculated evenly with spore suspension of a fresh culture of the organism. After inoculation they were incubated for 15 days at 25° C (± 1). Three replicates for each treatment were maintained. At the end of the incubation period the mycelial mats were harvested and dry weight was determined. The production of the antifungal substance was measured in terms of percentage germination of spores of *Colletotrichum capsici* in the filtrates. The spore germination test was done by hanging drop method. The results obtained has been presented in table 2.

TABLE 2

Showing the influence of various nutrient media on the growth and production of antifungal substance by Streptomyces sp. (Mean of three replicates)

Medium	Dry weight in gm.	Percentage spore germination
1. Sucrose nitrate	0·025	100·0
2. Glucose asparagin	0·016	100·0
3. Glycerol asparagin	0·014	100·0
4. Starch solution	0·222	64·5
5. Glucose peptone A	0·122	72·2
6. Glucose peptone B	0·066	78·5
7. Yeast extract	0·155	72·8

SUMMARY

Screening tests were done to study the antagonistic activity of a *Streptomyces* sp. Its growth and the production of an antifungal substance was determined on various nutrient media. Out of seven media tested, the medium containing starch supported the best growth and maximum yield of the antifungal substance was obtained.

ACKNOWLEDGEMENTS

Authors wish to express their thanks to Prof. S. Sinha, Head of the Botany Department, Agra College, Agra, for his help and suggestions. The first author is grateful to the Council of Scientific and Industrial Research, New Delhi, for award of the Fellowship.

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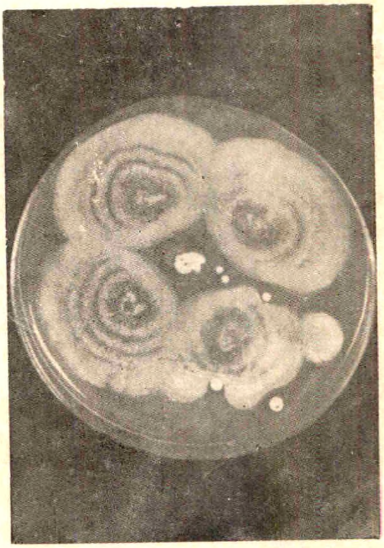

Plate 1. Showing antagonistic activity of a *Streptomyces* sp. (Isolate No. 21) against *Colletotrichum capsici*.

PIONEER SPECIES OF SOIL FUNGI OF YAMUNA RAVINE FORESTS IN RELATION TO SOIL FACTORS

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Ravines, caused by soil erosion, often involve extensive areas and present serious complications to forestry, agriculture and sociology. At Agra, ravines extend a few miles deep on the banks of the Yamuna river and in course of time have almost denuded the area of vegetation. *Acacia arabica* Willd., is being planted to afforest the ravines which run into a variety of topographies, each presenting its own problem in the development of plant cover and microbiological populations.

During the hot dry months of May and June there is little plant cover, but during the rainy season (July to October) some ground vegetation, consisting mostly of grasses, develops. The role of plant cover in the ecology of soil fungi has become increasingly evident in view of some recent contributions (Warcup 1951, Webley *et al.*, 1952, Tresner 1954, Saksena 1955, Thornton 1960 and Christensen 1960). In their turn, soil fungi are known to exert a variety of effects on the growth of higher plants. They may affect the availability of various nutritional substances, *viz.*, carbon, nitrogen and phosphorus and produce growth stimulating or growth regulating substances, such as auxins and phytohormones. The fungi benefit from plants through the decomposition and excretion products of the latter and may multiply in the "rhizosphere". The role of microorganisms in improving the physical condition of soil, notably soil aggregation, has recently received considerable attention. The structure of soil is greatly affected by the mycelium of fungi and the slimy cells of bacteria, as well as, by their metabolic products. The microorganisms differ greatly in soil aggregation properties and some of them are excellent soil binders. The fertility potential of the soil is sometimes measured on the basis of its microbiological activity, although the scope of its application in agriculture is limited because the reactions are brought about by several factors which are difficult to study in the laboratory.

The development of pioneer species of soil fungi in ravine soil is likely to take place when the habitat is denuded of vegetation and successional changes in fungal composition will take place as the plant cover develops. The composition of soil fungi in the untreated, denuded ravines will constitute the early pioneers and a study of these species is therefore important in the ecological investigations of the ravines.

MATERIALS AND METHODS

Observations were recorded from treated (afforested) and untreated areas in the Yamuna ravines of Kailash Forest Range of Brijbhoomi Forest Division, Agra. A/long bund road cuts across the ravines and runs for several miles separating the head side of the ravines from the river side. The present investigations were confined to the head side of the ravines. As pioneer species are expected in the hottest and most critical period of the year, the soil samples were collected during the month of June, 1959, before the outbreak of monsoon. The map (fig. 1) gives the idea of the area under investigation. The treated sites were chosen in Baberpur Block and the untreated ones in Mau Block.

The ravines present roughly four distinct topographies; top, slope, gully and valley flat. On the head side of the ravines, the first three topographies prevail. The slope is considerably spread out and shows various gradients, and can roughly be divided into four parts from the top to the gully. Symbols were given for each topography.

Replications—In both the treated and untreated blocks six sites, indicated as 1, 2—6, were selected at random in each of the topography. From each site, three samples of soil denoted by a, b and c were collected. Thus for each treated or untreated block 108 samples were taken. 216 samples in all were thus collected. The soil samples were taken with the help of galvanised iron borers 1½″ in diameter. The first 6″ of the surface soil was taken in each case and the samples were collected in sterilized paper bags.

Determination of soil factors—Soil temperature was recorded using soil thermometers on the day of soil collection. Soil moisture, pH and water-holding capacity were calculated following the methods given by Piper (1944). Humus content was determined by the ignition method described by Waksman (1952).

Isolation of Fungi—The dilution plate method, as described by Waksman (1927) was adopted. Isolations from each of the soil samples were made in triplicates. The plates were incubated at 25°C for eight days. The fungi were then transferred to culture slants for identification. Czapek's agar medium was used for isolations. For calculating the population in one milligram of the soil of a given topography, colonies appearing in petridishes were counted and the mean values calculated for six sites in three samples, each having three replications. The frequency, abundance and total number of fungi in each topography of both treated and untreated blocks were determined, following the standard ecological methods outlined by Weaver and Clements (1936) and Tansley (1946). The different scales given for frequency and abundance are those after Saksena (1955).

RESULTS

Fungal population in relation to soil factors—Table 1 and polygraphs (Fig 2.) are presented showing the number of fungal colonies in one milligram of soil, in relation to soil temperature, pH, moisture, water-holding capacity and humus.

TABLE 1

Fungal Population in Relation to Soil Factors of Different Topographies in Treated and Untreated Ravines.

Topographies (symbols)	Ravines	Soil temp. in °F	pH	Moisture %	Water-holding capacity %	Humus %	Fungal population per mgm of soil
R	Treated	117·1	8·3	1·062	32·819	2·914	117
	Untreated	118·1	8·2	2·601	29·908	3·418	84
S I	Treated	114·1	7·6	2·2776	31·648	4·057	117
	Untreated	116·1	8·1	1·685	28·233	2·799	102
S II	Treated	114·1	8·0	1·259	34·963	3·560	90
	Untreated	115·8	8·0	1·466	30·296	3·281	64
S III	Treated	113·9	7·4	1·436	31·936	2·957	127
	Untreated	116·1	8·2	1·548	27·724	2·469	47
S IV	Treated	110·4	7·1	2·043	35·620	2·989	149
	Untreated	114·6	7·8	1·285	26·529	2·328	52
G	Treated	110·7	7·1	5·843	37·042	3·488	884
	Untreated	115·0	7·8	2·236	28·884	2·889	187

In all the topographies, the fungal population is higher in the treated areas than in the untreated ones. In the ravine top, the total number of fungal colonies appears to be influenced by soil temperature and water holding capacity. In the first part of the slope (S I), the difference in the fungus population from that in the top is not marked enough, although soil factors are more favourable for the development of fungi in the slope (S I). The number of fungal colonies in the mid slope (S II & S III) is much higher in the treated (90 in S II and 127 in S III) than in the untreated (64 in S II and 47 in S III) area. In the treated area moderate temperature, greater water-holding capacity and higher humus content prevail, all being favourable for fungal multiplication. The same factors, with the addition of soil moisture operate in slope IV. In the gullys all the soil factors, except pH appear to have marked influence. The difference in the population of treated and the untreated part is greatly marked in the gully, the fungi being much more abundant in the afforested areas.

Frequency and abundance—The frequency and abundance of fungi in various topographies of the treated and untreated ravines are indicated in table 2.

A close examination of the data presented in table 2 reveals that out of the 19 species of fungi isolated from the soils, four, *viz.*, *Cunninghamella echinulata*, *Alternaria humicola*, *Aspergillus granulosis* and *A. terricola* are absent from the untreated part and occur only in the treated area. On the other hand, *Aspergillus terreus* is confined to the untreated area and is absent from the treated one. The fungi which are common to both the treated and untreated areas are: *Aspergillus niger*, *A. fumigatus*, *A. candidus*, *A. Sydowi*, *A. ustus*, *Rhizopus arrhizus*, *Spicaria divaricata*, *Trichoderma koningi*, *Fusarium* sp., *Oospora* sp., *Spondylocladium fumosum* and *Penicillium* sp. *Aspergillus niger*, *A fumigatus*, *A. candidus*, *Penicillium* sp., *Spicaria divaricata*, *Trichoderma koningi* and *Fusarium* sp. have a higher frequency in the treated part, while *Rhizopus arrhizus*, *Oospora* sp., and *A. sydowi* are more frequent in the untreated areas. *Aspergillus ustus* and *Spondylocladium fumosum* have generally the same frequency, both in the treated and the untreated area. The highest percentage frequency is shown by *Aspergillus niger* and *Penicillium* sp. Next in order are *Spicaria divericata*, *Rhizopus arrhizus*, *Trichoderma koningi*, *Aspergillus fumigatus* and *A. sydowi*. Restricted distribution is shown by the rest. The fungus population in terms of fungi per milligram of soil is presented in table 1. It indicates a significant trend with respect to various topographies and afforestation. In the treated part, the population increases from the ravine top (117) to the gully (844), except in the middle of the slope where the fungi are less abundant (90). A similar general trend is observed in the untreated area (top 84, mid. slope 64 and gully 187). The population of gully rises to a high figure, as compared to that in other topographies. The effect of afforestation seems to be marked only in the lower part of the slopes and the gully, since the respective population figures for treated (slope 149, gully 884) and untreated (slope 52, gully 187) areas are widely apart only in these contours. The abudance of some species of fungi appears to be affected with the change of topography and treatment. *Aspergillus niger* is more abundant in higher topographies of treated area but gives place to *Penicillium* sp. in lower parts of the slope and gully. In the untreated area, *Penicillium* sp. has the maximum abundance in all the topographies. As the lower slopes and gully approach, the abundance of *Rhizopus arrhizus* increases, while that of *Spicaria divaricata* decreases.

A study of the frequency of pioneer species in relation to topographies reveals that only five fungi, *viz.*, *Aspergillus niger*, *Rhizopus arrhizus*, *Penicillium* sp. *Trichoderma koningi* and *Aspergillus fumigatus* are influenced by the changing topographies, and hence by the related soil factors. From table 1 it can be concluded that soil moisture, water-holding capacity and humus content determine the fungal population in various topographies of the ravines, both in the treated and the untreated areas. Considering individually, the species of fungi react "differently" with the soil factors with respect to their frequency. *Aspergillus niger* is dominant in the ravine top, its frequency decreasing in the slope and down to the gully as the soil moisture, water-holding capacity and humus content increase. *Rhizopus arrhizus* behaves similarly. On the other hand, *Penicillium* sp., *Aspergillus fumigatus* and *Trichoderma koningi* fall in their frequency from the ravine top to the gully. The remaining fungi, *Aspergillus granulosis, A. ustus, Spicaria divaricata, Oospora sp., Fusarium* sp., *Spondylocladium fumosum, Alternaria humicola*, and *Cunninghamella echinulata* do not vary in their frequency with change in contour, hence their distribution is presumably not determined by those soil factors that vary with the topographies, but by the soil pH alone which remains fairly uniform in all the topographies.

ACKNOWLEDGEMENTS

We have great pleasure in expressing our thanks to the Divisional Forest Officer, Agra and Forest Range Officer, Kailash, for providing the facilities during collection of soil samples, and to Dr. K. C. Basu-Chaudhary for his keen interest and valuable help.

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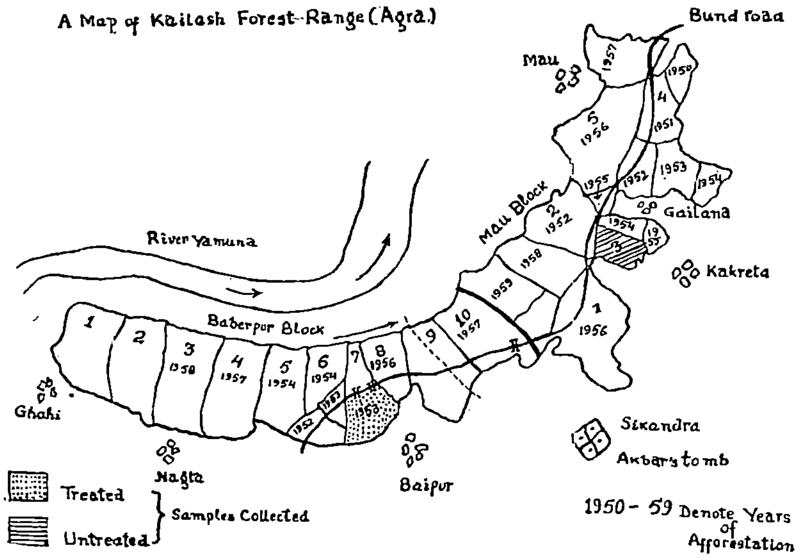
A Map of Kailash Forest-Range (Agra.)
Bund road
Mau
1957
1959
4
5
1956
1951
1953
1954
1955
1952
Gailana
Mau Block
2
1952
1954
3
1958
Kakreta
River Yamuna
1953
10
1957
1
1956
Baberpur Block
1
2
3
1958
4
1957
5
1954
6
1954
7
8
1956
9
1952
Ghahi
Nagla
Baipur
Sikandra
Akbar's tomb
Treated
Untreated
Samples Collected
1950 - 59 Denote Years of Afforestation

Fig. 1.

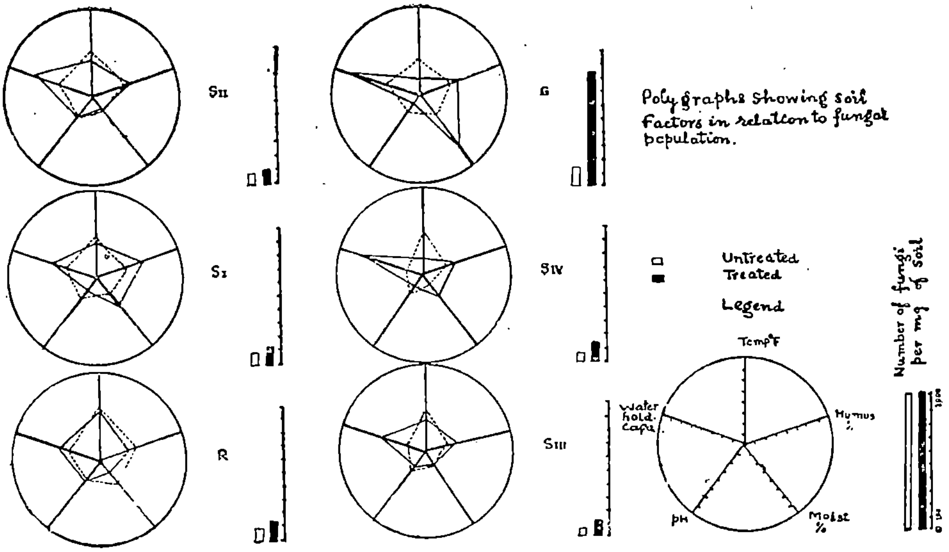
SII
SI
R
G
SIV
SIII
Polygraphs showing soil factors in relation to fungal population.
Untreated
Treated
Legend
Temp°F
Humus %
Moist %
pH
Water hold. capa.
Number of fungi per mg of soil

Fig. 2.

TABLE—2

Frequency and Abundance of Fungi in Various Topographies of Treated and Untreated Ravines.

Name of species	Ravine top (R)				Slope I (SI)				Slope II (SII)				Slope III(SIII)				Slope IV (SIV)				Gully (G)			
	TR		UNTR		TR		UNTR		TR		UNTR		TR		UNTR		TR		UNTR		TR		UNTR	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
Rhizopus arrhizus Fisch.	...	...	1	1	1	1	2	2	1	1	1	1	3	3	2	2	1	1	1	3	2	3	4	3
Cunninghamella echinulata Thaxter	...	...	...	...	1	...	...	...	1	...	...	...	1	...	...	...	1	1	...	...	...	...	...	...
Aspergillus candidus Link	...	...	1	1	1	5	...	...	1	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...
A. fumigatus Fresenius	1	1	2	1	2	3	1	1	2	1	1	2	1	1	1	1	1	1	1	1	2	3	1	1
A. granulos Raper & Thom	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
A. nidulans (Eidam) Winter	...	...	2	2	1	...	1	...	1	...	1	1	1	...	...	...	1	1	...	...	...	...	1	...
A. niger van Tiegh.	5	5	4	4	5	5	4	4	4	5	4	4	4	4	3	3	4	4	5	5	4	4	3	5
A. sydowi Thom & Raper	1	...	1	1	3	3	1	1	1	1	...	...	1	1	1	5	1	1	1	1	1	1	2	2
A. tamarii Kita	1	1	1	1	1	1	1	1	2	2	1	...	1	1	...	...	1	1	1	1	1	1	1	...
A. terreus Thom	...	...	1	...	...	...	1	1	...	...	1	1	...	...	1	1	...	...	...	...	...	...	1	...
A. terricola Marchel	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
A. ustus Thom & Church	...	...	1	...	1	1	1	...	1	1	...	...	1	...	1	1	1	...	...	...	...	...	...	...

(*Continued*)

TABLE 2 (*Continued*)

Frequency and Abundance of Fungi in Various Trpographies of Treated and Untreated Ravines.

Name of species	Ravine top (R)				Slope I (SI)				Slope II (SII)				Slope III (SIII)				Slope IV (SIV)				Gully (G)			
	TR		UNTR		TR		UNTR		TR		UNTR		TR		UNTR		TR		UNTR		TR		UNTR	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
Penicillium sp.	3	2	5	5	3	4	5	5	4	4	4	5	4	5	3	5	5	5	3	5	5	5	4	5
Trichoderma koningi Oudemans	1	1	2	1	2	1	1	1	1	1	...	...	2	2	...	...	1	...	...	...	2	2	1	...
Spicaria divaricata Oudemans	3	5	1	1	2	2	3	3	1	1	2	2	3	4	1	2	2	1	1	2	3	4	2	2
Oospora sP.	...	...	1	1	1	1	...	...	...	...	1	...	...	...	...	...	..	...	1	2	...	...	1	...
Spondylocladium fumosum Martius	...	...	1	...	1	...	...	...	1	1	...	...	1	...	...	...	1	...	1	1	...	...	1	1
Alternaria humicola Oudemans	...	...	...	...	1	...	...	..	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...
Fusarium sp.	...	...	1	...	1	1	1	1	1	1	1	1	2	1	1	1	1	...	1	1	1	1	1	...

TR=Treated; UNTR=Untreated; F=Frequency; A=Abundance

SOME INFINITE INTEGRALS INVOLVING GAUSS' HYPERGEOMETRIC SERIES

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1. Generalisations of Laplace integral

$$(1.1)\qquad f(s)=\int_0^\infty e^{-st}\,\phi(t)\,dt$$

have been given by Meijer (1941), Boas (1942) and Varma (1947, 1951).

In my previous papers I have taken the transform in the form

$$(1.2)\qquad f(s)=\int_0^\infty (2st)^\lambda\, W_{k,m}\,(2st)\phi(t)\,dt$$

which, when $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, reduces to (1.1)

In one of my papers I (1964) have evaluated some infinite integrals involving the transform (1.2) and in another paper I have proved the following theorem:—

Theorem. If

$$f(s)=\int_0^\infty (2su)^\lambda\, W_{k,m}\,(2su)\phi(u)\,du$$

and

$$\phi(u)=\int_0^\infty e^{-ut}\,\psi(t)\,dt$$

then

$$f(s)=\frac{\Gamma^*(\lambda\pm m+3/2)}{2s\Gamma(\lambda-k+2)}\int_0^\infty {}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2\\ \lambda-k+2\end{matrix}\,;\tfrac{1}{2}-\frac{t}{2s}\right\}\Psi(t)\,dt$$

provided Re $(\lambda\pm m+3/2)>0$, Re $s>0$, Re $(\mu+1)>0$, Re $\nu>0$,

where $\psi(t)=0(t^{\mu})$ for small t and $\psi(t)=0\,(e^{-t^{\nu}})$ for large t.

The object of this paper is to evaluate some new infinite integrals involving Gauss' hypergeometric series with the help of the above theorem and the infinite integrals evaluated in the previous paper.

$\Gamma^*(a\pm b)$ denotes $\Gamma(a+b).\Gamma(a-b)$ and ${}_2F_1\,(a\pm b;c;x)$ denotes ${}_2F_1\,(a+b,a-b;c;x)$

2. Examples:

Example (1). Let $\psi(t)=t^{\frac{1}{2}\nu}\mathrm{J}_\nu\,(at^{\frac{1}{2}})$

then on using result (40) of Erdelyi (1954 I, p. 245), we get

$$\phi(u)=(\tfrac{1}{2}a)^{\nu}\, u^{-\nu-1}\,\overset{\mathrm{W}}{e}{}^{-\frac{1}{4}a^2/u}\,, \qquad \mathrm{Re}\ \nu>-1$$

Therefore by the following result due to Goyal (1964)

$$\int_0^{\infty} (2sx)^{\lambda}\, \mathrm{W}_{k,m}\,(2sx)\,x^{-n}\, e^{-a/x}\, dx$$

$$(2.1)\qquad =2^{\lambda+3/2}\, s^{n-1}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{2^{m+r}\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\,\frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$(\mathrm{as})^{\frac{1}{2}(\lambda-n+m+r+3/2)}\,\mathrm{K}_{-(\lambda-n+m+r+3/2)}(2a^{\frac{1}{2}}s^{\frac{1}{2}})$$

$$+\frac{2^{-m+r}\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\,\frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\times(\mathrm{as})^{\frac{1}{2}(\lambda-n-m+r+3/2)}$$

$$\mathrm{K}_{-(\lambda-n-m+r+3/2)}\,(2a^{\frac{1}{2}}s^{\frac{1}{2}})\Bigg],$$

provided Re (as)>0 and $2m$ is not an integer, we have

$$\int_0^{\infty} {}_2\mathrm{F}_1\left\{\begin{matrix}\lambda\pm m+3/2\\ \lambda-k+2\end{matrix}\ ;\ \tfrac{1}{2}-\frac{t}{2s}\right\} t^{\frac{1}{2}\nu}\mathrm{J}_\nu\,(\mathrm{a}t^{\frac{1}{2}})\,\mathrm{d}t$$

$$=\frac{(\frac{1}{2}a)^{\nu}(2s)\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\int_0^{\infty}(2su)^{\lambda}\mathrm{W}_{k,m}\,(2\mathrm{su})\,u^{-\nu-1}\,e^{-\frac{1}{4}a^2/u}\,du$$

$$=\frac{4a^{\nu}s^{\nu+1}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\,\frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$\times(a^2s)^{\frac{1}{2}(\lambda-\nu+m+r+\frac{1}{2})}\,\mathrm{K}_{-(\lambda-\nu+m+r+\frac{1}{2})}\,(\mathrm{as}^{\frac{1}{2}})$$

$$+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\,\frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\,(\mathrm{a}^2s)^{\frac{1}{2}(\lambda-\nu-m+r+\frac{1}{2})}$$

$$\mathrm{K}_{-(\lambda-\nu-m+r+\frac{1}{2})}\,(\mathrm{as}^{\frac{1}{2}})\Bigg],$$

provided Re $s>0$, $a>0$, Re $\nu>-1$, Re $(\lambda\pm m+3/2)>0$ and $2m$ is not an integer.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we get

$$\int_0^\infty (s+t)^{-1} t^{\nu/2} J_\nu (at^{\frac{1}{2}})\, dt=2s^{\frac{1}{2}\nu} K_\nu (as^{\frac{1}{2}})$$

which gives result (10) of Erdelyi (1954 II, p. 225).

The result of example (1) can also be written in the form

$$\int_0^\infty {}_2F_1 (\alpha, \beta; \delta; \tfrac{1}{2}-\frac{t}{2s}) t^{\nu/2} J_\nu (at^{\frac{1}{2}})\, dt$$

$$=\frac{4a^\nu s^{\nu+1}\Gamma(\delta)}{\Gamma(\alpha)\Gamma(\beta)} \sum_{r=0}^{\infty} \frac{1}{r!} \left[\frac{\Gamma(\beta-\alpha)}{\Gamma(\delta-\alpha)} \frac{(\delta-\beta)_r}{(\alpha-\beta+1)_r} (a^2s)^{\frac{1}{2}(\alpha-\nu+r-1)}\right.$$

$$\times K_{\nu-r-\alpha+1} (as^{\frac{1}{2}})+\frac{\Gamma(\alpha-\beta)}{\Gamma(\delta-\beta)} \frac{(\delta-\alpha)_r}{(\beta-\alpha+1)_r} (a^2s)^{\frac{1}{2}(\beta-\nu+r-1)}$$

$$\left.\times K_{\nu-r-\beta+1} (as^{\frac{1}{2}}) \right],$$

provided Re $s>0$, $a>0$, Re $\alpha>0$, Re $\beta>0$, and Re $\nu>-1$
All other examples can similarly be changed.

Example (2). Let $\psi(t)=t^{-\frac{1}{2}} \cos (at^{\frac{1}{2}})$
then on using (37) of Erdelyi (1954 I, p. 245), we get

$$\phi(u)=\pi^{\frac{1}{2}} u^{-\frac{1}{2}} e^{-\frac{1}{4}a^2/u}$$

Hence by (2.1) and the theorem of section 1, we have

$$\int_0^\infty {}_2F_1 \left\{\begin{matrix}\lambda\pm m+\frac{3}{2}\\ \lambda-k+2\end{matrix} ;\ \tfrac{1}{2}-\frac{t}{2s}\right\} t^{-\frac{1}{2}} \cos (at^{\frac{1}{2}})\, dt$$

$$=\frac{2\pi^{\frac{1}{2}}s\,\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+\frac{3}{2})} \int_0^\infty (2su)^\lambda W_{k,m} (2su)\, u^{-\frac{1}{2}} e^{-\frac{1}{4} a^2/u}\, du$$

$$=\frac{2^{\frac{3}{2}}\pi^{\frac{1}{2}} s^{\frac{1}{2}}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+\frac{3}{2})} \sum_{r=0}^{\infty} \frac{1}{r!} \left[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)} \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}\right.$$

$$(a^2s)^{\frac{1}{2}(\lambda+m+r+1)} K_{-(\lambda+m+r+1)} (as^{\frac{1}{2}})+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)} \frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}$$

$$\left.(a^2s)^{\frac{1}{2}(\lambda-m+r+1)} K_{-(\lambda-m+r+1)} (as^{\frac{1}{2}}) \right],$$

provided Re $s>0$, $a>0$ and $|\arg s| <\pi$

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^{\infty} (s+t)^{-1}\ t^{-\frac{1}{2}} \cos\,(at^{\frac{1}{2}})\ dt=2^{\frac{1}{2}}\pi^{\frac{1}{2}}a^{\frac{1}{2}}s^{-\frac{1}{4}}\,\mathrm{K}_{-\frac{1}{2}}\,(as^{\frac{1}{2}})$$

$$=\pi s^{-\frac{1}{2}}\ e^{-as^{\frac{1}{2}}},\ a>0,\quad |\arg s|<\pi$$

which gives result (55) of Erdelyi (1954 II, p. 221).

Example (*3*). Let $\psi(t)=\sin\,(at^{\frac{1}{2}})$
then by result (38) of Erdelyi (1954 I, p. 245), we have

$$\phi(u)=\tfrac{1}{2}\,a\,\pi^{\frac{1}{2}}\,u^{-3/2}\ e^{-\frac{1}{4}a^2/u}\ ,\ \mathrm{Re}\ u>0$$

Hence on using (2.1) we get

$$\int_0^{\infty} {}_2F_1 \left\{ \begin{matrix} \lambda\pm m+\frac{8}{2} \\ \lambda-k+2 \end{matrix} ;\ \frac{1}{2}-\frac{t}{2s} \right\} \sin\,(at^{\frac{1}{2}})\ \mathrm{dt}$$

$$=\frac{as\ \pi^{\frac{1}{2}}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+\frac{3}{2})}\int_0^{\infty} (2su)^{\lambda}\ W_{k,m}\ (2su)\ u^{-\frac{8}{2}}\ e^{-\frac{1}{4}a^2/u}\ du$$

$$=\frac{2^{\frac{3}{2}}\pi^{\frac{1}{2}}\,as^{\frac{8}{2}}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+\frac{3}{2})}\sum_{r=0}^{\infty}\frac{1}{r!}\left[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}\right.$$

$$(a^2s)^{\frac{1}{2}(\lambda+m+r)}\,\mathrm{K}_{-(\lambda+m+r)}\ (as^{\frac{1}{2}})$$

$$+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\ (a^2s)^{\frac{1}{2}(\lambda-m+r)}$$

$$\left.\times\,\mathrm{K}_{-(\lambda-m+r)}\ (as^{\frac{1}{2}})\right]$$

provided Re $s>0$, $a>0$ and $|\arg s|\angle\pi$.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we get

$$\int_0^{\infty} (s+t)^{-1}\ \sin\,(at^{\frac{1}{2}})\ \mathrm{dt}=2^{\frac{1}{2}}\pi^{\frac{1}{2}}a^{\frac{1}{2}}s^{\frac{1}{4}}\,\mathrm{K}_{\frac{1}{2}}\ (as^{\frac{1}{2}})$$

$$=\pi e^{-as^{\frac{1}{2}}},\ a>0,\ |\arg s|\ \angle\pi$$

which gives result (36) of Erdelyi (1954 II, p. 219).

Example (*4*). Let $\psi\ (t)=\sin\,(at^{\frac{1}{2}})-at^{\frac{1}{2}}\ \cos\ (at^{\frac{1}{2}})$
then by (39) of Erdelyi (1954 I, p. 245), we have

$$\phi(u)=\tfrac{1}{4}\pi^{\frac{1}{2}}a^3\,u^{-\frac{5}{2}}\,e^{-\frac{1}{4}a^2/u}$$

Hence on using (2.1) we get

$$\int_0^\infty {}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2\\ \lambda-k+2\end{matrix};\ \tfrac{1}{2}-\frac{t}{2s}\right\}\left\{\sin\,(at^{\frac{1}{2}})-(at^{\frac{1}{2}})\cos\,(at^{\frac{1}{2}})\right\}dt$$

$$=\frac{\pi^{\frac{1}{2}}a^3s\Gamma(\lambda-k+2)}{2\Gamma^*(\lambda\pm m+3/2)}\int_0^\infty (2su)^\lambda\, W_{k,m}\,(2su)\; u^{-5/2}\; e^{-\frac{1}{4}a^2/u}\;du$$

$$=\frac{2^{\frac{3}{2}}\pi^{\frac{1}{2}}a^3s^{\frac{5}{2}}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\;\frac{(\frac{1}{2}+m-k)r}{(2m+1)_r}$$
$$\times\ (a^2s)^{\frac{1}{2}(\lambda+m+r-1)}\;K_{-(\lambda+m+r-1)}\,(as^{\frac{1}{2}})+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}$$
$$\times\frac{(\frac{1}{2}-m-k)r}{(1-2m)r}\;(a^2s)^{\frac{1}{2}(\lambda-m+r-1)}\;K_{-(\lambda-m+r-1)}\,(as^{\frac{1}{2}})\Bigg],$$

provided Re $s>0$, $a>0$ and $|\arg s|<\pi$.

Cor. If $\lambda=-\frac{1}{4}$. $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^\infty (s+t)^{-1}\left\{\sin\,(at^{\frac{1}{2}})-at^{\frac{1}{2}}\cos\,(at^{\frac{1}{2}})\right\}dt$$

$$=2^{\frac{1}{2}}\;\pi^{\frac{1}{2}}\;c^{\frac{3}{2}}\;s^{\frac{3}{4}}\;K_{\frac{3}{2}}\;(as^{\frac{1}{2}})$$

$$=\pi\, e^{-as^{\frac{1}{2}}}\;(1+as^{\frac{1}{2}}),\ a>0,\ |\arg s|<\pi.$$

Example (5). Let $\psi\,(t)=\cosh\,[\nu\cosh^{-1}\,(1+2t)]\;(t^2+\frac{1}{2}t)^{-\frac{1}{2}}$ then by result (19) of Erdelyi (1954 I, p. 169) we have

$$\phi(u)=e^{\frac{1}{2}u}\;K_\nu\;(\tfrac{1}{2}u)$$

Hence on using the following result due to Goyal (1964)

$$(2.2)\quad \int_0^\infty (2sx)^\lambda\; W_{k,\,m}\,(2sx)\;x^\mu\, e^{qx}\,K_n\;(\tfrac{1}{2}x)\;dx$$

$$=\pi^{\frac{1}{2}}\;(2s)^{\lambda+\frac{1}{2}}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\;\frac{(\frac{1}{2}+m-k)r}{(2m+1)r}\;(2s)^{m+r}$$
$$\times\frac{\Gamma^*(\lambda+\mu+m+r\pm n+3/2)}{\Gamma(\lambda+\mu+m+r+2)}\times\ {}_2F_1\left\{\begin{matrix}\lambda+\mu+m+r\pm n+3/2\\ \lambda+\mu+m+r+2\end{matrix};\ \tfrac{1}{2}-(s-q)\right\}+$$
$$\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\;\frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\;(2s)^{-m+r}\;\frac{\Gamma^*(\lambda+\mu-m+r\pm n+3/2}{\Gamma(\lambda+\mu-m+r+2)}$$
$$\times\ {}_2F_1\left\{\begin{matrix}\lambda+\mu-m+r\pm n+3/2\\ \lambda+\mu-m+r+2\end{matrix};\ \tfrac{1}{2}-(s-q)\right\}\Bigg],$$

provided Re $(\lambda+\mu\pm m\pm n+3/2)>0$, Re $(s-q)>-\frac{1}{2}$, we have

$$\int_0^\infty {}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2\\ \lambda-k+2\end{matrix};\tfrac{1}{2}-\frac{t}{2s}\right\}\cosh\Big[\nu\cosh^{-1}(1+2t)\Big](t^2+\tfrac{1}{2}t)^{-\frac{1}{2}}\,dt$$

$$=\frac{\pi^{\frac{1}{2}}(2s)^{\lambda+3/2}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}(2s)^{m+r}$$

$$\times\frac{\Gamma^*(\lambda+m+r\pm\nu+3/2)}{\Gamma(\lambda+m+r+2)}\,{}_2F_1\left\{\begin{matrix}\lambda+m+r\pm\nu+3/2\\ \lambda+m+r+2\end{matrix};1-s\right\}+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}$$

$$\times(2s)^{-m+r}\frac{\Gamma^*(\lambda-m+r\pm\nu+3/2)}{\Gamma(\lambda-m+r+2)}\,{}_2F_1\left\{\begin{matrix}\lambda-m+r\pm\nu+3/2\\ \lambda-m+r+2\end{matrix};1-s\right\}\Bigg]$$

provided Re $(\lambda\pm m\pm\nu+3/2)>0$ Re $s>0$.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^\infty (s+t)^{-1}\cosh\Big[\nu\cosh^{-1}(1+2t)\Big](t^2+\tfrac{1}{2}t)^{-\frac{1}{2}}\,dt$$

$$=2\Gamma(1\pm\nu)\,{}_2F_1(1\pm\nu\,;3/2\,;1-s)$$

provided Re $(1\pm\nu)>0$, Re $s>0$

Example (6). Let $\psi(t)=e^{-at}$

then $\phi(u)=\int_0^\infty e^{-ut}e^{-at}\,dt=\dfrac{1}{u+a}$, R $(u+a)>0$

Therefore

$$\int_0^\infty {}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2\\ \lambda-k+2\end{matrix};\tfrac{1}{2}-\frac{t}{2s}\right\}e^{-at}\,dt$$

$$=\frac{(2s)\,\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\int_0^\infty(2su)^{\lambda}\,W_{k,m}(2su)\,(u+a)^{-1}\,du$$

$$=\frac{(2s)^{\lambda+\frac{3}{2}}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$\times(2s)^{m+r}\,\Gamma(\lambda+m+r+3/2)\,(a)^{\lambda+m+r+\frac{1}{2}}\,\Psi(\lambda+m+r+3/2,\lambda+m+r+3/2;as)$$

$$+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}(2s)^{-m+r}\Gamma(\lambda-m+r+3/2)\,(a)^{\lambda-m+r+\frac{1}{2}}$$

$$\times\Psi(\lambda-m+r+3/2,\lambda-m+r+3/2;as)\Bigg],$$

provided Re $(\lambda\pm m+3/2)>0$ Re $s>0$, Re $a>0$ $|\arg s|<\pi$, on using a result due to Goyal (1964).

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^\infty (s+t)^{-1}\, e^{-at}\, dt = \Psi(1,\, 1;\ as)$$

$$= e^{as}\,\Gamma(0,\, as);\ |\arg s| < \pi,\ \mathrm{Re}\ a > 0$$

which gives result (4) of Erdelyi (1954 I, p. 137).

Example (7). Let $\psi(t)=(1+t^{-1})^{\frac{1}{2}\mu}\mathrm{P}_{\nu}^{\mu}(1+2t)$

then by result (2) of Erdelyi (1954 I, p, 179) we have

$$\phi\ (u)=u^{-1}\ e^{\frac{1}{2}u}\ \mathrm{W}_{\mu,\ \nu+\frac{1}{2}}\ (u),\ \mathrm{Re}\ \mu<1$$

Hence on using the following result due to Goyal (1964)

$$(2.3)\quad \int_0^\infty (2sx)^{\lambda}\ \mathrm{W}_{k,\,m}\ (2sx)\ x^{\mu}\ e^{qx}\ \mathrm{W}_{l,n}\ (x)\ dx$$

$$= (2s)^{\lambda+\frac{1}{2}} \sum_{r=0}^{\infty} \frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}\ (2s)^{m+r}$$

$$\times \frac{\Gamma^*(\lambda+\mu+m+r\pm n+2)}{\Gamma(\lambda+\mu+m+r+5/2-l)} \times {}_2\mathrm{F}_1\left\{\begin{matrix}\lambda+\mu+m+r\pm n+2\\ \lambda+\mu+m+r+5/2-l\end{matrix};\ \tfrac{1}{2}-(s-q)\right\}$$

$$+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{(\frac{1}{2}-m-k)_r}{(-2m+1)_r} \times (2s)^{-m+r}\ \frac{\Gamma^*(\lambda+\mu-m+r\pm n+2)}{\Gamma(\lambda+\mu-m+r+5/2-l)}$$

$${}_2\mathrm{F}_1\left\{\begin{matrix}\lambda+\mu-m+r\pm n+2\\ \lambda+\mu-m+r+5/2-l\end{matrix};\ \tfrac{1}{2}-(s-q)\right\}\Bigg],$$

provided $\mathrm{Re}\ (\lambda+\mu\pm m\pm n+2)>0$, $\mathrm{Re}\ (s-q)>-\frac{1}{2}$, we have

$$\int_0^\infty {}_2\mathrm{F}_1\left\{\begin{matrix}\lambda\pm m+3/2\\ \lambda-k+2\end{matrix};\ \tfrac{1}{2}-\frac{t}{2s}\right\}\ (1+t^{-1})^{\frac{1}{2}\mu}\ \mathrm{P}_{\nu}^{\mu}\ (1+2t)\ dt$$

$$=\frac{(2s)^{\lambda+\frac{3}{2}}\ \Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)} \sum_{r=0}^{\infty} \frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}\ (2s)^{m+r}$$

$$\times \frac{\Gamma(\lambda+m+r+\nu+3/2)\ \Gamma(\lambda+m+r-\nu+\frac{1}{2})}{\Gamma(\lambda+m+r-\mu+3/2)}$$

$${}_2\mathrm{F}_1\left\{\begin{matrix}\lambda+m+r+\nu+3/2,\ \lambda+m+r-\nu+\frac{1}{2}\\ \lambda+m+r-\mu+3/2\end{matrix};\ 1-s\right\}$$

$$\times \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{(\frac{1}{2}-m-k)r}{(1-2m)r}\ (2s)^{-m+r}$$

$$\frac{\Gamma(\lambda-m+r+\nu+3/2)\ \Gamma(\lambda-m+r-\nu+\frac{1}{2})}{\Gamma(\lambda-m+r-\mu+3/2)}$$

$$\times {}_2\mathrm{F}_1\left\{\begin{matrix}\lambda-m+r+\nu+3/2,\ \lambda-m+r-\nu+\frac{1}{2}\\ \lambda-m+r-\mu+3/2\end{matrix};\ 1-s\right\}\Bigg],$$

provided $\mathrm{Re}\ (\lambda\pm m+\nu+3/2)>0$, $\mathrm{Re}\ (\lambda\pm m-\nu+\frac{1}{2})>0$, $\mathrm{Re}\ \mu<1$ and $\mathrm{Re}\ s>0$.

Cor. If we put $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we get

$$\int_0^\infty (s+t)^{-1} \quad (1+t^{-1})^{\frac{1}{2}\mu} \mathrm{P}_\nu^\mu \, (1+2t) \; dt$$

$$=\frac{\Gamma(\nu+1)\ \Gamma(-\nu)}{\Gamma(1-\mu)} \ {}_2F_1\ (\nu+1,\ -\nu;\ 1-\mu;\ 1-s)$$

provided Re $(\nu+1)>0$, Re $(-\nu)>0$, Re $s>0$ and Re $\mu<1$.

which after a little change of variables and parameters reduces to result (4) of Erdelyi (1954 II, p. 321).

Example (8). Let $\psi\ (t) =t^{-\frac{1}{2}\mu}\ (1+t)^{-\frac{1}{2}}\ \mathrm{P}_\nu^\mu\Big[(1+t^{\frac{1}{2}})\Big]$ then by result (8) of Erdelyi (1954 I, p. 180), we have

$$\phi(u)=2^{\mu}u^{\frac{1}{2}\mu-\frac{3}{4}}\ e^{\frac{1}{2}u}\,\mathrm{W}_{\frac{1}{2}\mu-\frac{1}{4},\ \frac{1}{2}\nu+\frac{1}{4}}\,(u),\ \mathrm{R}e\ \mu<1$$

Therefore on using (2.3) we get

$$\int_0^\infty {}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2 \\ \lambda-k+2\end{matrix}\ ;\ \tfrac{1}{2}-\frac{t}{2s}\right\} t^{-\frac{1}{2}\mu}\ (1+t)^{-\frac{1}{2}}\ \mathrm{P}_\nu^\mu\Big[\ (1+t^{\frac{1}{2}})\ \Big]dt$$

$$=\frac{2^{\mu}\ \ (2s)^{\lambda+\frac{3}{2}}\ \Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$\times\ \ (2s)^{m+r}\ \frac{\Gamma(\lambda+m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+3/2)\ \Gamma\ (\lambda+m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+1)}{\Gamma\ (\lambda+m+r+2)}$$

$$\times\ \ {}_2F_1\left\{\begin{matrix}\lambda+m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+3/2,\ \lambda+m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+1;\ \ 1-s \\ \lambda+m+r+2\end{matrix}\right\}$$

$$+\ \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \ \frac{(\frac{1}{2}-m-k)_r}{(1-2m)r}$$

$$\times\ \ (2s)^{-m+r}\ \ \frac{\Gamma(\lambda-m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+3/2)\ \Gamma(\lambda-m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+1)}{\Gamma(\lambda-m+r+2)}$$

$$\times\ \ {}_2F_1\left\{\begin{matrix}\lambda-m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+3/2,\ \lambda-m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+1;\ \ 1-s \\ \lambda-m+r+2\end{matrix}\right\}\Bigg],$$

provided Re $(\lambda\pm m+\frac{1}{2}\mu+\frac{1}{2}\nu+3/2)>0$, Re $(\lambda\pm m+\frac{1}{2}\mu-\frac{1}{2}\nu+1)>0$, Re $s>0$ and Re $\mu<1$.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we get

$$\int_0^\infty (s+t)^{-1}\ \ t^{-\frac{1}{2}\mu}\ (1+t)^{-\frac{1}{2}}\ \mathrm{P}_\nu^\mu\Big[(1+t^{\frac{1}{2}})\ \Big]dt$$

$$=2^{\mu+1}\pi^{-\frac{1}{2}}\Gamma(1+\tfrac{1}{2}\mu+\tfrac{1}{2}\nu)\ \Gamma(\tfrac{1}{2}+\tfrac{1}{2}\mu-\tfrac{1}{2}\nu)$$

$$\times\ \ {}_2F_1\ \ (1+\tfrac{1}{2}\mu+\tfrac{1}{2}\nu,\ \tfrac{1}{2}+\tfrac{1}{2}\mu-\tfrac{1}{2}\nu;\ 3/2;\ 1-s)$$

provided Re $(1+\frac{1}{2}\mu+\frac{1}{2}\nu)>0$, Re $(\frac{1}{2}+\frac{1}{2}\mu-\frac{1}{2}\nu)>0$ Re $s>0$ and Re $\mu<1$.

Example (9). Let $\psi(t)=\Big[t(1+t)\Big]^{-\frac{1}{2}\mu} P_\nu^\mu(1+2t)$

then by result (1) of Erdelyi (1954 I, p. 179), we have

$$\phi(u)=\pi^{-\frac{1}{2}}\, u^{\mu-\frac{1}{2}}\, e^{\frac{1}{2}u} K_{\nu+\frac{1}{2}}(\tfrac{1}{2}u),\ \mathrm{Re}\,\mu<1$$

Hence on using (2.2) we get

$$\int_0^\infty {}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2 \\ \lambda-k+2\end{matrix};\tfrac{1}{2}-\frac{t}{2s}\right\}[t(1+t)]^{-\frac{1}{2}\mu} P_\nu^\mu(1+2t)\,dt$$

$$=\frac{(2s)^{\lambda+3/2}\,\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\,\frac{(\frac{1}{2}+m-k)r}{(2m+1)r}\,(2s)^{m+r}$$

$$\times\frac{\Gamma(\lambda+\mu+m+r+\nu+3/2)\,\Gamma(\lambda+\mu+m+r-\nu+\frac{1}{2})}{\Gamma(\lambda+\mu+m+r+3/2)}$$

$${}_2F_1\left\{\begin{matrix}\lambda+\mu+m+r+\nu+3/2,\ \lambda+\mu+m+r-\nu+\frac{1}{2} \\ \lambda+\mu+m+r+3/2\end{matrix};1-s\right\}$$

$$+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\,\frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\,(2s)^{-m+r}$$

$$\frac{\Gamma(\lambda+\mu-m+r+\nu+3/2)\,\Gamma(\lambda+\mu-m+r-\nu+\frac{1}{2})}{\Gamma(\lambda+\mu-m+r+3/2)}$$

$$\times\ {}_2F_1\left\{\begin{matrix}\lambda+\mu-m+r+\nu+3/2,\ \lambda+\mu-m+r-\nu+\frac{1}{2} \\ \lambda+\mu-m+r+3/2\end{matrix};1-s\right\}\Bigg],$$

provided Re $(\lambda+\mu\pm m+\nu+3/2)>0$, Re $(\lambda+\mu\pm m-\nu+\frac{1}{2})>0$, Re $s>0$, Re $\mu<1$ and $|\arg s|<\pi$.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^\infty (s+t)^{-1}\left\{t(1+t)\right\}^{-\frac{1}{2}\mu} P_\nu^\mu(1+2t)\,dt$$

$$=\frac{\Gamma(\mu+\nu+1)\,\Gamma(\mu-\nu)}{\Gamma(\mu+1)}\,{}_2F_1(\mu+\nu+1,\mu-\nu;\mu+1;1-s)$$

Re $(\mu+\nu+1)>0$, Re $(\mu-\nu)>0$, Re $\mu<1$ and $|\arg s|<\pi$, Re $s>0$ which after a change of parameters and limits of integration reduces to a particular case of result (10) of Erdelyi (1954 II, p. 322).

Example (10). Let $\psi(t)=t^{-\frac{1}{2}\mu} P_\nu^\mu\Big[(1+t)^{\frac{1}{2}}\Big)$

then by (7) of Erdelyi (1954 I, p. 180), we have

$$\phi(u)=2^{\mu}\,u^{\frac{1}{2}\mu-5/4}\,e^{\frac{1}{2}u}\,W_{\frac{1}{2}\mu+\frac{1}{4},\ \frac{1}{2}\nu+\frac{1}{4}}(u),\ \mathrm{Re}\,\mu<1$$

Hence on using (2.3) we get

$$\int_0^\infty {}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2 \\ \lambda-k+2\end{matrix};\tfrac{1}{2}-\frac{t}{2s}\right\} t^{-\frac{1}{2}\mu} P_\nu^\mu\Big[(1+t)^{\frac{1}{2}}\Big]dt$$

$$
\begin{aligned}
&= \frac{2^{\mu}\,(2s)^{\lambda+3/2}\,\Gamma(\lambda-k+2)}{\Gamma^{*}(\lambda\pm m+3/2)} \sum_{r=0}^{\infty} \frac{1}{r!} \Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)} \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r} (2s)^{m+r} \\
&\quad \times \frac{\Gamma(\lambda+m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+1)\Gamma(\lambda+m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+\frac{1}{2})}{\Gamma(\lambda+m+r+1)} \\
&\qquad {}_2F_1\left\{\begin{matrix}\lambda+m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+1,\ \lambda+m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+\frac{1}{2} \\ \lambda+m+r+1\end{matrix} ; 1-s\right\} \\
&\quad + \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)} \frac{(\frac{1}{2}-m-k)r}{(1-2m)r} \\
&\qquad (2s)^{-m+r} \frac{\Gamma(\lambda-m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+1)\ \Gamma(\lambda-m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+\frac{1}{2})}{\Gamma(\lambda-m+r+1)} \\
&\quad \times\ {}_2F_1\left\{\begin{matrix}\lambda-m+r+\frac{1}{2}\mu+\frac{1}{2}\nu+1,\ \lambda-m+r+\frac{1}{2}\mu-\frac{1}{2}\nu+\frac{1}{2} \\ \lambda-m+r+1\end{matrix} ;\ 1-s\right\} \Bigg],
\end{aligned}
$$

Provided Re $(\lambda\pm m+\frac{1}{2}\mu+\frac{1}{2}\nu+1)>0$, Re $(\lambda\pm m+\frac{1}{2}\mu-\frac{1}{2}\nu+\frac{1}{2})>0$, Re $\mu<1$ and Re $s>0$.

Cor. If $\lambda=-\frac{1}{4}, k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$
\int_0^{\infty} (s+t)^{-1}\, t^{-\frac{1}{2}\mu}\, P_{\nu}^{\mu} \left[(1+t^{\frac{1}{2}})\right] dt
$$

$$
= 2^{\mu}\, \pi^{-\frac{1}{2}}\, \Gamma\left(\frac{\mu+\nu+1}{2}\right) \Gamma\left(\frac{\mu-\nu}{2}\right) {}_2F_1 \left(\frac{\mu+\nu+1}{2}, \frac{\mu-\nu}{2}; \frac{1}{2}; 1-s\right)
$$

If we further put $s=0$ and change the limits of integration, it reduces to result (3) of Erdelyi (1954 II, p. 320).

Example (11). Let $\psi(t) = t^{c-1}\, {}_2F_1\,(a, b; c; -t)$ then by result (9) of Erdelyi (1954 I, p. 294) we get

$$
\phi\ (u)=\Gamma(c)\ u^{\frac{1}{2}(a+b-2c-1)}\ e^{\frac{1}{2}u} W_{\frac{1}{2}(1-a-b),\frac{1}{2}(a-b)}(u), \text{ Re } c>0.
$$

Hence on using (2.3), we have

$$
\int_0^{\infty} {}_2F_1 \left\{\begin{matrix}\lambda\pm m+3/2 \\ \lambda-k+2\end{matrix} ;\ \frac{1}{2}-\frac{t}{2s}\right\} t^{c-1}\, {}_2F_1\,(a, b; c; -t)\ dt
$$

$$
\begin{aligned}
&= \frac{(2s)^{\lambda+3/2}\ \Gamma(c)\ \Gamma(\lambda-k+2)}{\Gamma^{*}(\lambda\pm m+3/2)} \sum_{r=0}^{\infty} \frac{1}{r!} \Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)} \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r} (2s)^{m+r} \\
&\quad \times \frac{\Gamma(\lambda+m+r+a-c+3/2)\ \Gamma(\lambda+m+r+b-c+3/2)}{\Gamma(\lambda+m+r+a+b-c+3/2)} \\
&\qquad {}_2F_1\left\{\begin{matrix}\lambda+m+r+a-c+3/2,\ \lambda+m+r+b-c+3/2 \\ \lambda+m+r+a+b-c+3/2\end{matrix} ; 1-s\right\} \\
&\quad + \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{(\frac{1}{2}-m-k)r}{(1-2m)_r}\ (2s)^{-m+r} \\
&\qquad \frac{\Gamma(\lambda-m+r+a-c+3/2)\ \Gamma(\lambda-m+r+b-c+3/2)}{\Gamma(\lambda-m+r+a+b-c+3/2)} \\
&\quad \times\ {}_2F_1\left\{\begin{matrix}\lambda-m+r+a-c+3/2,\ \lambda-m+r+b-c+3/2 \\ \lambda-m+r+a+b-c+3/2\end{matrix} ;\ 1-s\right\} \Bigg],
\end{aligned}
$$

Provided Re $(\lambda\pm m+a-c+3/2)>0$, Re $(\lambda\pm m+b-c+3/2)>0$, Re $c>0$ Re $s>0$ and $|\arg s| \angle \pi$.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we get

$$\int_0^\infty (s+t)^{-1}\, t^{c-1}\, {}_2F_1\,(a,\, b;\, c;\, -t)\, dt$$

$$=\frac{\Gamma(c)\,\Gamma(a-c+1)\,\Gamma(b-c+1)}{\Gamma(a+b-c+1)}\; {}_2F_1 \left\{\begin{matrix} a-c+1,\ b-c+1 \\ a+b-c+1 \end{matrix};\, 1-s\right\}$$

Re $(a-c+1)>0$, Re $(b-c+1)>0$, Re $c>0$ $|\arg s|<\pi$ and Re $s>0$, which is verified by result (10) of Erdelyi (1954 II, p. 400).

Example (12). Let $\psi(t)=t^{-\nu}\, e^{-\frac{1}{2}a/t}\, D_{2\nu-1}(2^{\frac{1}{2}}\, a^{\frac{1}{2}}\, t^{-\frac{1}{2}})$

then by (12) of Erdelyi (1954 I, p. 211), we have

$$\phi\,(u)=2^{\nu-\frac{1}{2}}\,\pi^{\frac{1}{2}}\,u^{\nu-1}\,e^{-2a^{\frac{1}{2}}u^{\frac{1}{2}}}$$

Hence on using the following result due to Goyal (1964)

$$(2.4)\quad \int_0^\infty (2sx)^{\lambda}\, W_{k,m}\ (2sx)\, x^{\mu}\, e^{-2a^{\frac{1}{2}}x^{\frac{1}{2}}}\, dx$$

$$=\frac{(2s)^{-\mu}}{s}\, e^{\frac{1}{2}a/s} \sum_{r=0}^{\infty} \frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$\Gamma(2\lambda+2\mu+2m+2r+3)\,D_{-(2\lambda+2\mu+2m+2r+3)}\ \left\{ (2a/s)^{\frac{1}{2}} \right\} + \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}$$

$$\times \frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\ \Gamma(2\lambda+2\mu-2m+2r+3)\ \ D_{-(2\lambda+2\mu-2m+2r+3)}$$

$$\left\{ (2a/s)^{\frac{1}{2}} \right\}\Bigg],$$

provided Re $(2\lambda+2\mu\pm2m+3)>0$, Re $s>0$ and $2m$ is not an integer, we have

$$\int_0^\infty {}_2F_1 \left\{\begin{matrix} \lambda\pm m+3/2 \\ \lambda-k+2 \end{matrix};\, \tfrac{1}{2}-\frac{t}{2s}\right\} t^{-\nu}\, e^{-\frac{1}{2}a/t}\ D_{2\nu-1}\ (2^{\frac{1}{2}}a^{\frac{1}{2}}t^{-\frac{1}{2}})\, dt$$

$$=\frac{2\pi^{\frac{1}{2}}\ s^{1-\nu}\ \Gamma(\lambda-k+2)}{\Gamma^{*}(\lambda\pm m+3/2)}\, e^{\frac{1}{2}a/s} \sum_{r=0}^{\infty}\ \frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$\times\Gamma(2\lambda+2\nu+2m+2r+1)\ D_{-(2\lambda+2\nu+2m+2r+1)}\ \left\{(2a/s)^{\frac{1}{2}}\right\}+$$

$$\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\quad \frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\Gamma(2\lambda+2\nu-2m+2r+1)$$

$$D_{-(2\lambda+2\nu-2m+2r+1)}\ \left\{(2a/s)^{\frac{1}{2}}\right\}\Bigg],$$

provided Re $(2\lambda+2\nu\pm2m+1)>0$, Re $s>0$, Re $a>0$ and $2m$ is not an integer.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^\infty (s+t)^{-1} t^{-\nu} e^{-\frac{1}{2}a/t} \, D_{2\nu-1} \, (2^{\frac{1}{2}} a^{\frac{1}{2}} t^{-\frac{1}{2}}) \, dt$$

$$= \pi^{\frac{1}{2}} s^{-\nu} e^{\frac{1}{2}a/s} \, \Gamma(2\nu) \, D_{-2\nu}\left[(2a/s)^{\frac{1}{2}} \right]$$

Re $\nu>0$, Re $a>0$ and Re $s>0$

which after a little change of variables and parameters reduces to result (6) of Erdelyi (1954 II, p. 396).

Example (13). Let $\psi(t)=t^{-a} G^{l,\,n}_{p,\,q}\left(ct \,\middle|\, \begin{matrix} a_1,\ldots\ldots, a_p \\ b_1,\ldots\ldots, b_q \end{matrix} \right)$

then by (34) of Erdelyi (1954 I, p. 222), we get

$$\phi(u)=u^{a-1} \, G^{l,\, n+1}_{p+1,\, q}\left(\frac{c}{u} \,\middle|\, \begin{matrix} a, a_1\ldots\ldots, a_p \\ b_1,\ldots\ldots\ldots, b_q \end{matrix} \right)$$

provided $p<q$, $|\arg c|<(l+n-\frac{1}{2}p-\frac{1}{2}q)\pi$, Re $a<$ Re b_j+1, $j=1,\ldots\ldots, l$.

Hence on using the following result due to Goyal (1964)

$$(2.5) \quad \int_0^\infty (2sx)^\lambda \, W_{k,\mu}(2sx) \, x^{-a} \, G^{m\; n}_{p\; q}\left(cx \,\middle|\, \begin{matrix} a_1,\ldots\ldots, a_p \\ b_1,\ldots\ldots, b_q \end{matrix} \right) dx$$

$$= (2s)^{\lambda+\frac{1}{2}} \sum_{r=0}^{\infty} \frac{1}{r!} \left[\frac{\Gamma(-2\mu)}{\Gamma(\frac{1}{2}-\mu-k)} \, \frac{(\frac{1}{2}+\mu-k)_r}{(2\mu+1)_r} \, (2s)^{\mu+r} \right.$$

$$\times \; (s)^{a-\lambda-\mu-r-3/2} \, G^{m,\, n+1}_{p+1,\, q}\left(\frac{c}{s} \,\middle|\, \begin{matrix} a-\lambda-\mu-r-\frac{1}{2}, a_1, \ldots\ldots, a_p \\ b_1, \ldots\ldots, b_q \end{matrix} \right)$$

$$+ \; \frac{\Gamma(2\mu)}{\Gamma(\frac{1}{2}+\mu-k)} \, \frac{(\frac{1}{2}-\mu-k)_r}{(1+2\mu)_r} \, (2s)^{-\mu+r} (s)^{a-\lambda+\mu-r-3/2}$$

$$\left. G^{m,\, n+1}_{p+1,\, q}\left(\frac{c}{s} \,\middle|\, \begin{matrix} a-\lambda+\mu-r-\frac{1}{2}, a_1,\ldots\ldots, a_p \\ b_1,\ldots\ldots, b_q \end{matrix} \right) \right],$$

provided $p+q<2(m+n)$, $|\arg c|<(m+n-\frac{1}{2}p-\frac{1}{2}q)\pi$, Re $(a-\lambda-\mu-\frac{1}{2})<b_j+1$, $j=1,\ldots\ldots, m.$,

we have

$$\int_0^\infty {}_2F_1 \left\{ \begin{matrix} \lambda\pm m+3/2 \\ \lambda-k+2 \end{matrix} ; \frac{1}{2}-\frac{t}{2s} \right\} t^{-a} \, G^{l,\, n}_{p,\, q}\left(ct \,\middle|\, \begin{matrix} a_1,\ldots\ldots, a_p \\ b_1,\ldots\ldots, b_q \end{matrix} \right) dt$$

$$= \frac{(2s)\;\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)} \int_0^\infty (2su)^\lambda \, W_{k,m} \, (2su) u^{a-1} \, G^{l,\, n+1}_{p+1,\, q}$$

$$\left(\frac{c}{u} \,\middle|\, \begin{matrix} a, a_1,\ldots\ldots, a_p \\ b_1, \ldots\ldots, b_q \end{matrix} \right) du$$

$$= \frac{(2s)\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\int_0^{\infty}(2su)^{\lambda}\, W_{k,m}\ (2su)u^{a-1}\, G^{n+1,\,l}_{q,\,p+1}\left(\frac{u}{c}\,\middle|\,\begin{matrix}1-b_1,\ldots,\ 1-b_q\\ 1-a,\ 1-a_1,\ldots 1-a_p\end{matrix}\right)du$$

$$= \frac{(2s)^{\lambda+3/2}\ \Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}\ (2s)^{m+r}$$

$$\times\ (s)^{-(\lambda+a+m+r+\frac{1}{2})}\, G^{l+1,\ n+1}_{p+1,\ q+1}\left(cs\,\middle|\,\begin{matrix}a,\ a_1,\ldots\ldots,\ a_p\\ \lambda+a+m+r+\frac{1}{2},\ b_1,\ldots,b_q\end{matrix}\right)$$

$$+\ \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\ (2s)^{-m+r}\ (s)^{-(\lambda+a-m+r+\frac{1}{2})}$$

$$\times\ G^{\,l+1,\ n+1}_{\,p+1,\ q+1}\left(cs\,\middle|\,\begin{matrix}a,\ a_1,\ldots\ldots,\ a_p\\ \lambda+a-m+r+\frac{1}{2},\ b_1,\ldots\ldots,b_q\end{matrix}\right)\Bigg],$$

provided $p+q<2(l+n)$, $|\arg c|<(l+n-\frac{1}{2}p-\frac{1}{2}q)\pi$, $\mathrm{Re}\ (\frac{1}{2}-\lambda-a\pm m)<2-a_j$, $j=1,\ \ldots\ldots,\ n$, $\mathrm{Re}\ a<\mathrm{Re}\ b_j+1$, $j=1,\ldots\ldots,\ l$.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^{\infty}(s+t)^{-1}\,t^{-a}\ \ G^{\,l,\ n}_{\,p,\ q}\left(ct\,\middle|\,\begin{matrix}a_1,\ldots\ldots,\ a_p\\ b_1,\ldots\ldots,\ b_q\end{matrix}\right)dt$$

$$=\ s^{-a}\ \ G^{\,l+1,\ n+1}_{\,p+1,\ q+1}\left(cs\,\middle|\,\begin{matrix}a,\ a_1,\ldots\ldots\ldots,\ a_p\\ a,\ b_1,\ldots\ldots\ldots,\ b_q\end{matrix}\right)$$

$\mathrm{Re}\ a_j<\mathrm{Re}\ a+1$, $j=1,\ldots\ldots\ldots,\ n$; $\mathrm{Re}\ \ a<\mathrm{Re}\ \ b_j+1$, $j=1,\ldots\ldots\ldots,\ l$; $p+q<2(l+n)$; $|\arg c|<(l-n-\frac{1}{2}p-\frac{1}{2}q)\pi$; $|\arg s|<\pi$.

If we further put $a=0$, it reduces to result (55) of Erdelyi (1954 II, p. 232).

Example (14). Let $\psi\ (t)=t^{b-1}\ E(a::t^{-1})$
then by result (33) of Erdelyi (1954 I, p. 222), we have

$\phi\ (u)=u^{-b}\ E(a,\ b:\ :\ u)$, $\mathrm{Re}\ b>0$.

Hence on using the following infinite integral due to Goyal (1964)—

$$(2.6)\quad \int_0^{\infty}(2sx)^{\lambda}\ W_{k,m}\ \ (2sx)\ \ x^{\mu}e^{qx}\ E(\alpha,\ \beta\ :\ :\ x)\ dx$$

$$=\ \Gamma(\alpha)\Gamma(\beta)\,(2s)^{\lambda+\frac{1}{2}}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}\ (2s)^{m+r}$$

$$\times\ \frac{\Gamma(\lambda+\mu+m+r+\alpha+3/2)\ \ \Gamma(\lambda+\mu+m+r+\beta+3/2)}{\Gamma(\lambda+\mu+m-r+\alpha+\beta+3/2)}$$

$$\times\ {}_2F_1\left\{\begin{matrix}\lambda+\mu+m+r+\alpha+3/2,\ \lambda+\mu+m+r+\beta+3/2\\ \lambda+\mu+m+r+\alpha+\beta+3/2\end{matrix}\ ;\ 1-(s-q)\right\}$$

$$+\ \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\ \frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}$$

$$\times \quad (2s)^{-m+r} \frac{\Gamma(\lambda+\mu-m+r+\alpha+3/2)\ \Gamma(\lambda+\mu-m+r+\beta+3/2)}{\Gamma(\lambda+\mu-m+r+\alpha+\beta+3/2)}$$

$$\times \ {}_2F_1 \left\{ \begin{matrix} \lambda+\mu-m+r+\alpha+3/2,\ \lambda+\mu-m+r+\beta+3/2 \\ \lambda+\mu-m+r+\alpha+\beta+3/2 \end{matrix} ;\ 1-(s-q) \right\} \Bigg],$$

Re $(\lambda+\mu \pm m+\alpha+3/2)>0$, Re $(\lambda+\mu \pm m+\beta+3/2)>0$, Re $(s-q)>0$, we have

$$\int_0^{\infty} {}_2F_1 \left\{ \begin{matrix} \lambda \pm m+3/2 \\ \lambda-k+2 \end{matrix} ;\ \tfrac{1}{2}-\frac{t}{2s} \right\} t^{b-1}\, E(a : : t^{-1})\, dt$$

$$= \frac{(2s)^{\lambda+\frac{3}{2}}\ \Gamma(\lambda-k+2)}{\Gamma^*(\lambda \pm m+3/2)}\ \Gamma(a)\ \Gamma(b) \sum_{r=0}^{\infty} \frac{1}{r!} \Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)} \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r} (2s)^{m+r}$$

$$\times \frac{\Gamma(\lambda-b+m+r+a+3/2)\ \Gamma(\lambda+m+r+3/2)}{\Gamma(\lambda+m+r+a+3/2)}$$

$${}_2F_1 \left\{ \begin{matrix} \lambda-b+m+r+a+3/2,\ \lambda+m+r+3/2 \\ \lambda+m+r+a+3/2 \end{matrix} ;\ 1-s \right\}$$

$$+ \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)} \quad \frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r} (2s)^{-m+r}$$

$$\frac{\Gamma(\lambda-b-m+r+a+3/2)\ \Gamma(\lambda-m+r+3/2)}{\Gamma(\lambda-m+r+a+3/2)}$$

$$\times \ {}_2F_1 \left\{ \begin{matrix} \lambda-b-m+r+a+3/2,\ \lambda-m+r+3/2 \\ \lambda-m+r+a+3/2 \end{matrix} ;\ 1-s \right\} \Bigg],$$

Re $(\lambda \pm m+a-b+3/2)>0$, Re $(\lambda \pm m+3/2)>0$, Re $s>0$.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $=\pm\frac{1}{4}$ we have

$$\int_0^{\infty} (s+t)^{-1}\, t^{b-1}\, E(a : : t^{-1})\, dt$$

$$= \frac{\Gamma(a)\ \Gamma(b)\ \Gamma(a-b+1)}{\Gamma(a+1)} \ {}_2F_1 \left\{ \begin{matrix} a-b+1,\ 1 \\ a+1 \end{matrix} ;\ 1-s \right\},$$

Re $(a-b+1)>0$, Re $s>0$.

Example (15). Let $\psi(t)=t^{-\frac{1}{2}(n+1)}\, e^{-a/t}\, He_n\, (2^{\frac{1}{2}} a^{\frac{1}{2}} t^{-\frac{1}{2}})$

then by (18) of Erdelyi (1954 I, p. 173), we have

$$\phi(u)=2^{\frac{1}{2}n} \pi^{\frac{1}{2}}\, u^{\frac{1}{2}n-\frac{1}{2}} e^{-2a^{\frac{1}{2}} u^{\frac{1}{2}}}, \text{ Re } a>0, \text{ Re } u>0.$$

Hence on using (2.4) we get

$$\int_0^{\infty} {}_2F_1 \left\{ \begin{matrix} \lambda \pm m+3/2 \\ \lambda-k+2 \end{matrix} ;\ \tfrac{1}{2}-\frac{t}{2s} \right\} t^{-\frac{1}{2}(n+1)} e^{-a/t}\, He_n\, (2^{\frac{1}{2}} a^{\frac{1}{2}} t^{-\frac{1}{2}})\, dt$$

$$= \frac{23/2\pi^{\frac{1}{2}}\ s^{\frac{1}{2}(1-n)}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda \pm m+3/2)} e^{\frac{1}{2}a/s} \sum_{r=0}^{\infty} \frac{1}{r!} \Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)} \ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$\times\ \Gamma(2\lambda+n+2m+2r+2)\ D_{-(2\lambda+n+2m+2r+2)}\left\{(2a/s)^{\frac{1}{2}}\right\}+\frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}$$

$$\times\frac{(\frac{1}{2}-m-k)_r}{(1-2m)_r}\ \Gamma(2\lambda+n-2m+2r+2)\ D_{-(2\lambda+n-2m+2r+2)}\left\{(2a/s)^{\frac{1}{2}}\right\}\Bigg],$$

provided Re $(2\lambda+n\pm2m+2)>0$, Re $s>0$, Re $a>0$ and $(2m)$ is not an integer.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we get

$$\int_0^{\infty}(s+t)^{-1}\,t^{-\frac{1}{2}(n+1)}\ e^{-a/t}\ \mathrm{He}_n\ (2^{\frac{1}{2}}a^{\frac{1}{2}}t^{-\frac{1}{2}})\ dt$$

$$=2^{\frac{1}{2}}\ \pi^{\frac{1}{2}}\ s^{-\frac{1}{2}(n+1)}\ e^{\frac{1}{2}\,a/s}\ \Gamma(n+1)\ D_{-(n+1)}\Big[\ (2a/s)^{\frac{1}{2}}\Big]$$

Re $(n+1)>0$, Re $s>0$ and Re $a>0$.

Example (*16*). Let $\psi\ (t)=t^{-\frac{1}{2}}e^{-a/t}$
then by result (6) of Erdelyi (1954 I, p. 246), we get

$$\phi(u)=\pi^{\frac{1}{2}}\ u^{-\frac{1}{2}}\ e^{-2a^{\frac{1}{2}}u^{\frac{1}{2}}},\ \text{Re}\ a\geqslant0.$$

Hence on using (2.4) we have

$$\int_0^{\infty}{}_2F_1\left\{\begin{matrix}\lambda\pm m+3/2\\ \lambda-k+2\end{matrix}\ ;\ \frac{1}{2}-\frac{t}{2s}\right\}t^{-\frac{1}{2}}e^{-a/t}\quad dt$$

$$=\frac{2^{3/2}\ s^{\frac{1}{2}}\ \pi^{\frac{1}{2}}\Gamma(\lambda-k+2)}{\Gamma^*(\lambda\pm m+3/2)}e^{\frac{1}{2}a/s}\sum_{r=0}^{\infty}\frac{1}{r!}\Bigg[\frac{\Gamma(-2m)}{\Gamma(\frac{1}{2}-m-k)}\ \frac{(\frac{1}{2}+m-k)_r}{(2m+1)_r}$$

$$\times\ \Gamma(2\lambda+2m+2r+2)\ \ D_{-(2\lambda+2m+2r+2)}\left\{\ (2a/s)^{\frac{1}{2}}\right\}$$

$$+\ \frac{\Gamma(2m)}{\Gamma(\frac{1}{2}+m-k)}\frac{\Gamma(\frac{1}{2}-m-k)_r}{(1-2m)_r}$$

$$\times\ \Gamma(2\lambda-2m+2r+2)\ \ D_{-(2\lambda-2m+2r+2)}\ \left\{(2a/s)^{\frac{1}{2}}\right\}\Bigg],$$

provided Re $(\lambda\pm m+1)>0$, Re $s>0$, Re $a\geqslant0$ and $2m$ is not an integer.

Cor. If $\lambda=-\frac{1}{4}$, $k=\frac{1}{4}$ and $m=\pm\frac{1}{4}$, we have

$$\int_0^{\infty}(s+t)^{-1}t^{-\frac{1}{2}}\,e^{-a/t}\ \ dt=2^{\frac{1}{2}}\pi^{\frac{1}{2}}s^{-\frac{1}{2}}e^{\frac{1}{2}a/s}\ \ D_{-1}\Big[(2a/s)^{\frac{1}{2}}\Big],$$

Re $a>0$, $|\arg s|<\pi$,
which is verified by result (19) of Erdelyi (1954 II, p. 218).

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EMPIRICAL RELATION BETWEEN THE TIME OF SETTING AND CONCENTRATION OF SOAP GELS IN SEVERAL NON-AQUEOUS MEDIA

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Gels of soaps, chiefly of sodium and potassium salts of palmitic, stearic and oleic acids have been prepared by several workers in large number of non-aqueous solvents, by heating the mixture of the soap and a non-aqueous solvent to a temperature until the soap dissolves and then allowing the solution thus formed to cool down to a suitable lower temperature. Most of these workers have also measured the time of setting of the gels prepared by them with changes in the concentration of soap and the temperature at which solution is cooled and with the addition of some substances which also dissolve in the non-aqueous solvent, by Fleming's[1] method in accordance with the definition given by Prasad.[2] The times of setting of gels of sodium and potassium oleate, sodium and potassium palmitate and sodium and potassium stearate in pinene were thus measured by Prasad, Hattiangdi and Vishvanath.[3] The times of setting of sodium oleate and sodium erucate gels in a fraction of turpentine have been recently measured by Seth.[4]

It has been found by author that the available data on the variation of time of setting (t_s) with the change in the concentration (c) of soaps formed under the same condition are given by relation $(t_s - k_1 c^{-m_1})(t_s - k_2 c^{-m_2}) = 0$, where k_1, k_2, m_1 and m_2 are constants at a particular temperature. The results obtained are given in tables 1-8. The close agreement between the calculated and observed values of t_s in all cases justifies the generality of the suggested relation.

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TABLE 1

Time of setting of sodium oleate gels in a fraction of turpentine.

c	$T=40^\circ$ $k_1=2\cdot0\times10^{-8}$ $k_2=1\cdot718$ $m_1=7\cdot875$ $m_2=0\cdot275$		$T=50^\circ$ $k_1=4\cdot4\times10^{-5}$ $k_2=1\cdot928$ $m_1=4\cdot800$ $m_2=0\cdot325$		$T=60^\circ$ $k_1=1\cdot34\times10^{-4}$ $k_2=2\cdot388$ $m_1=4\cdot436$ $m_2=0\cdot325$		$T=70^\circ$ $k_1=5\cdot1\times10^{-2}$ $k_2=2\cdot494$ $m_1=2\cdot096$ $m_2=0\cdot411$		$T=80^\circ$ $k_1=4\cdot6\times10^{-2}$ $k_2=3\cdot093$ $m_1=2\cdot415$ $m_2=0\cdot386$	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.).	t_s (cal.)
0·075	15·000	14·510	...	...	...	...	...	...	...	...
0·080	6·000	8·690	8·000	8·102	10·000	9·837	...	...	...	...
0·085	...	...	7·000	6·059	8·000	7·519	9·000	8·943	...	...
0·090	3·500	3·441	4·566	4·606	6·000	5·835	...	...	...	...
0·100	3·250	3·236	4·100	4·075	5·050	5·048	6·400	6·362	12·000	11·960
0·110	...	...	...	...	...	...	...	...	10·000	9·501
0·120	...	...	...	...	...	...	...	...	7·500	7·700
0·125	3·000	3·043	3·750	3·789	4·660	4·695	5·866	5·861	7·000	6·977
0·130	...	...	...	...	...	...	5·616	5·768	6·800	6·798
0·140	...	...	...	...	...	...	5·450	5·595	6·616	6·607
0·150	2·850	2·894	3·616	3·572	4·416	4·424	5·300	5·439	6·416	6·433
0·175	2·750	2·774	3·416	3·397	4·166	4·208	5·050	5·105	6·083	6·061
0·200	2·650	2·674	3·250	3·253	4·050	4·029	4·800	4·832	5·650	5·757
0·225	2·583	2·589	3·166	3·130	3·800	3·878	4·600	4·604	5·466	5·500
0·250	2·500	2·573	3·000	3·025	3·733	3·747	4·416	4·409	5·283	5·282

TABLE 2

Time of setting of sodium erucate gels in a fraction of turpentine.

c	T=40° $k_1=6\cdot92\times10^{-2}$ $k_2=2\cdot4970$ $m_1=2\cdot2200$ $m_2=0\cdot1665$		T=50° $k_1=2\cdot4\times10^{-3}$ $k_2=3\cdot4830$ $m_1=4\cdot1340$ $m_2=0\cdot1630$		T=60° $k_1=5\cdot51\times10^{-1}$ $k_2=4\cdot8570$ $m_1=1\cdot4550$ $m_2=0\cdot1210$		T=70° $k_1=8\cdot718\times10^{-1}$ $k_2=6\cdot4400$ $m_1=1\cdot3820$ $m_2=0\cdot1540$	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)
0·125	7·000	6·997	...	...	...	...	...	...
0·140	...	...	8·250	8·132	...	...	...	...
0·150	4·583	4·668	6·500	6·112	8·716	4·708	12·000	11·990
0·155	...	...	5·500	5·338	...	...	...	...
0·160	3·900	4·046	4·750	4·681	8·133	7·929	11·000	10·970
0·170	3·500	3·537	4·650	4·649	...	...	...	...
0·175	3·316	3·316	4·600	4·628	6·900	6·960	10·000	9·694
0·180	...	...	...	...	6·600	6·679	9·500	9·322
0·190	...	...	...	...	6·183	6·173	8·666	8·650
0·195	...	...	...	...	5·950	5·946	8·350	8·349
0·200	3·250	3·261	4·466	4·425	5.900	5·899	8·250	8·250
0·225	3·200	3.199	4·416	4·441	5·850	5·816	8·166	8·102
0·250	3·150	3·143	4·366	4·366	5·750	5·742	8·000	7·973
0·275	3·100	3·093	4·300	4·298	5·683	5·676	7·866	7·856
0·300	3·050	3.049	4·250	4·238	5·616	5·616	7.750	7·752

TABLE 3

Time of setting of sodium oleate gels in pinene.[3]

c	$T=40°$ $k_1=1\cdot1730$ $k_2=0\cdot6440$ $m_1=0\cdot2970$ $m_2=0\cdot6020$		$T=50°$ $k_1=0\cdot8873$ $k_2=0\cdot6127$ $m_1=0\cdot4775$ $m_2=0\cdot6933$		$T=60°$ $k_1=0\cdot8403$ $k_2=0\cdot5767$ $m_1=0\cdot5952$ $m_2=0\cdot8458$		$T=70°$ $k_1 0=\cdot1289$ $k_2 0=\cdot6721$ $m_1=1\cdot5020$ $m_2=0\cdot8256$		$T=80°$ $k_1=0\cdot2545$ $k_2—0\cdot8795$ $m=_1 1\cdot3600$ $m_2=0\cdot7973$	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s) cal.)	t_s (obs.)	t_s (cal.)
0·01	11·000	4·606	...	...	...	...	...	...	...	...
0·02	3·750	3·749	5·750	5.744	20·000	8·624	...	...	...	...
0·03	3·250	3·324	5·000	4·733	9.000	6·775	25·000	24·980	30·000	29·970
0·04	3·000	3·051	4·000	4·125	6·000	5·709	17·000	16·200	23·000	20·270
0·05	2·916	2·855	3·500	3·709	5·000	4·998	12·000	11·600	17·000	14·960
0·07	2·583	2·584	3·000	3·158	4·000	4·091	7·000	6·997	8·500	9·469
0·10	2·333	2·325	2·666	2·664	3·250	3·309	4·500	4·501	5·832	5·830
0·15	2·000	2·060	2·283	2·283	2·600	2·599	3·166	3·221	4·000	3·990
0·20	1·700	1·697	2·083	1·870	2·250	2·250	2·500	2·539	3·000	3·174
0·25	1·416	1·484	1·666	1·603	1·800	1·862	2·083	2·112	2·416	2·656
0.30	1·250	1·329	1·416	1·412	1·583	1·596	1·832	1·818	2·200	2·297
0·35	1·166	1·212	1·250	1·269	1·416	1·402	1·583	1·600	2·000	2.031
0·40	1·083	1·118	1·133	1·156	1·250	1·251	1·416	1·433	1·832	1·826
0·45	0·916	1·041	1·066	1·066	1·133	1.133	1·300	1·300	1·666	1·663

TABLE 4

Time of setting of sodium stearate gels in pinene.[3]

c	$T=40°$ $k_1=0\cdot9469$ $k_2=0\cdot8718$ $m_1=0\cdot7007$ $m_2=0\cdot8102$		$T=50°$ $k_1=1\cdot4730$ $k_2=0\cdot8841$ $m_1=0\cdot4712$ $m_2=0\cdot9354$		$T=60°$ $k_1=1\cdot2620$ $k_2=0\cdot7905$ $m_1=0\cdot6826$ $m_2=1\cdot2030$		$T=70°$ $k_1=1\cdot2630$ $k_2=$ ... $m_1=0\cdot7685$ $m_2=$ ...		$T=80°$ $k=0\cdot3325$ $k_2^1=1\cdot2450$ $m_1=2\cdot0660$ $m_2=0\cdot9147$	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)
0·25	2·500	2·501	2·832	2·831	3·250	3·251	3·666	3·665	5·832	5·829
0·30	2·200	2·201	2·583	2·597	2·866	2·871	3·166	3·185	4·000	3·999
0·35	2·000	2·040	2·416	2·415	2·583	2·583	2·832	2·830	3·250	3·253
0·40	1·832	1·831	2·083	2·083	2·400	2·380	2·583	2·554	2·832	2·878
0·45	1·666	1·664	1·866	1·865	2·083	2·065	2·333	2·333	2·583	2·584

TABLE 5

Time of setting of sodium palmitate gels in pinene.[3]

c	T=40° k_1=0·3210 k_2=0·8050 m_1=1·6330 m_2=0·8659		T=50° k_1=0·0575 k_2=0·8873 m_1=3·1580 m_2=0·8496		T=60° k_1=0·0081 k_2=1·0210 m_1=5·0380 m_2=0·8203		T=70° k_1=0·0553 k_2=1·1020 m_1=3·8800 m_2=0·8943		T=80° k_1=0·0559 k_2=0·4347 m_1=4·4920 m_2=2·5510	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal)	t_s (obs.)	t_s (cal.)
0·10	10·832	13·790	...	...	...	...	...	...	...	...
0·15	7·133	7·111	23·000	22·980	...	...	...	...	...	...
0·20	4·533	4·445	11·000	9·270	27·020	27·020	...	...	...	...
0·25	3·000	3·095	4·583	4·582	6·500	8·778	12·000	11·990	...	...
0·30	2·300	2·293	2·666	2·467	3·500	3·502	6·166	5·909	12·500	12·480
0·35	2·000	1·997	2·166	2·164	2·416	2·415	3·250	3·247	6·250	6·241
0·40	1·750	1·779	1·916	1·932	2·166	2·165	2·500	2·500	4·500	4·500
0·45	1·633	1·607	1·750	1·748	1·966	1·965	2·250	2·251	3·333	3·333

TABLE 6

Time of setting of potassium oleate gels in pinene.[3]

c	T=40° k_1=1·3980 k_2=0·9718 m_1=0·2225 m_2=0·4578		T=50° k_1=1·0810 k_2=0·9784 m_1=0·4384 m_2—0·5627		T=60° k_1=1·1240 k_2= ... m_1=0·4935 m_2— ...		T=70° k_1=0·0553 k_2= ... m_1=0·5489 m_2= ...		T=80° k_1=0·9090 k_2=1·3270 m_1=0·8195 m_2=0·4917	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)
0·10	2·333	2·333	2·966	2·966	3·500	3·501	4·100	4·098	6·000	5·999
0·15	2·133	2·132	2·333	2·482	2·832	2·866	3·433	3·279	4·250	4·302
0·20	2·000	2·000	2·166	2·189	2·300	2·487	2·800	2·800	3·500	3·399
0·25	1·832	1·833	2·000	1·985	2·200	2·228	2·416	2·477	2·832	2·831
0·30	1·700	1·686	1·832	1·832	2·000	2·036	2·166	2·242	2·400	2·399
0·35	1·600	1·571	1·766	1·766	1·866	1·887	2·000	2·060	2·250	2·223
0·40	1·483	1·478	1·666	1·639	1·750	1·766	1·916	1·914	2·083	2·082
0·45	1·400	1·401	1·533	1·533	1·666	1·666	1·800	1·795	1·966	1·965

TABLE 7

Time of setting of potassium stearate gels in pinene.[3]

c	T=40° k_1=0·0029 k_2=0·2608 m_1=3·0850 m_2=1·2120		T=50° k_1=0·0039 k_2=0·4201 m_1=3·0830 m_2=1·1070		T=60° k_1=0·0073 k_2=0·6448 m_1=2·9830 m_2=1·0240		T=70° k_1=0·0032 k_2=0·8110 m_1=3·4730 m_2=1·0820	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)
0·08	7·066	7·020	9·550	9·393	13·750	13·660	20·800	20·640
0·09	4·666	4·882	6·500	6·536	9·083	9·614	12·916	13·710
0·10	3·550	3·527	4·800	4·722	7·066	7·020	9·583	9·508
0·15	2·600	2·599	3·433	3·430	4·500	4·498	6·316	6·316
0·20	2·083	1·834	2·750	2·495	3·800	3·351	5·133	4·627
0·25	1·400	1·400	1·950	1·945	2·666	2·667	3·633	3·634

TABLE 8

Time of setting of potassium palmitate gels in pinene.[3]

c	T=30° k_1=0·0220 m_1=2·5430		T=40° k_1=0·0719 m_1=2·1910	
	t_s (obs.)	t_s (cal.)	t_s (obs.)	t_s (cal.)
0·08	12·416	13·550	...	...
0·09	9.916	10·040	14·083	14·060
0·10	5·500	7·681	11·416	11·160
0·15	2·750	2·738	4·333	4·590
0·20	1·550	1·318	2·666	2·444
0·25	0·750	0·747	1·500	1·499

SOIL MICROFUNGI AND OTHER EDAPHIC FACTORS IN RELATION TO *CAPPARIS-APLUDA-PERGULARIA* ASSOCIATION IN YAMUNA RAVINES

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The surface vegetation, be it a forest cover (Shetye 1954, Saksena 1955, and Tresner *et al.* 1954) or an agricultural crop (Guillemat and Montegut 1956, 1957 and 1958), is well known to have its influence upon the composition of soil microflora. This effect is partly due to accumulation of organic matter which follows decomposition of litter and partly to the development of a rhizosphere and rhizoplane microflora associated with different species of higher plants.

Capparis decidua (Forsk.) Pax., *Apluda mutica* Linn. and *Pergularia daemia* (Forsk.) Chiov. form a distinct association which is of wide occurence in the Yamuna ravines near Agra. The present investigation deals with the effect of this association on soil factors, studied by comparing the microfungi and soil conditions within the association with those outside this association. Apart from the above three dominant species some grasses *e.g.*, *Cynodon dactylon* Pers., *Eleusine aegyptiaca* Desf. and *Eragrostis pilosa* Beav., and some weeds, *viz.*, *Euphorbia hirta* L., *Borreria hispida* (Linn.) Schum, *Tephrosia perpurea* Pers., *Pluchea lanceolata* C. B. and *Micrococca mercurialis* (Linn.) Benth. are common to both the areas.

Materials and Methods

Soil Sampling:

Soil samples from areas with *Capparis-Apluda-Pergularia* association (designated as locality 'A') and those where the above association did not occur (designated as locality 'B') were collected during August, 1963, from Yamuna ravines at Chhalesar (Agra) with the help of sterilized metal borers, 6″ long and 1½″ in diameter, kept in sterilized polythene bags and brought to the laboratory for further experiments. The samples thus collected represented the first six inches of soil of the two areas.

Isolation and Identification of Microfungi:

Isolations were made following Warcup's soil plate method (1950). Martin's Rose Bengal-Streptomycin (Allen 1950) and Czapek's agar media were used. To check the growth of bacteria in Petri plates having Czapek's agar medium, one ml. of 0·2% lactic acid solution made in sterilized water was added to each plate before pouring the medium. The plates were incubated at room temperature (28-35°C) for a week. Colony counts were made on the 8th day and the fungi appearing in Petri plates were transferred, after purification, to slants of Czapek's agar medium for storage and identification. Identification of the isolates was done and confirmed by comparison with authentic stock cultures (previously identified by Commonwealth Mycological Institute, Kew) stored in this laboratory.

Determination of Frequency and Abundance of Fungi :

The frequency and abundance of different species of fungi were calculated and categorised following the scales outlined by Saksena (1955). Individual and total fungal populations were also calculated.

Determination of Soil Factors :

Moisture, water-holding capacity, and pH of soil samples were determined using methods outlined by Piper (1952). Soil humus was determined by 'ignition method' described by Waksman (1952). Organic carbon and total nitrogen were estimated using methods outlined by Jackson (1958) and Piper (1952), respectively.

RESULTS

The distribution, population, frequency and abundance of different species of fungi isolated from soils of both the areas are shown in table 1. The values of moisture, humus, water-holding capacity, organic carbon, nitrogen, pH and organic carbon nitrogen ratio are given in table 2. The polygraphs and histograms are given to represent the set of soil conditions and total fungal population and total number of fungal types respectively of both the areas.

DISCUSSION

As is evident from table 1 the total fungal population is slightly higher in soils of area 'B' (102·442) than that in soils in area 'A' (98·884). This might possibly be due to the fact that soils of area 'A' containing root exudates of the plants in the association do not provide as good a substratum as is provided by soils where these plants are absent ('B'). Although the total fungal population is higher in soils outside the association (*i. e.*, in 'B') the total number of species of fungi is fewer. Thirtyeight species of fungi were isolated from soils of 'A' while only thirtyone species were obtained from 'B'. Twentyfive species are common to both the areas. Thirteen species, *viz.*, *Mucor hiemalis*, *Trichoderma lignorum* *Aspergillus chevalieri*, *A. fumigatus* (strain 3) *A. sulphureus*, *A. variecolor*, *Penicillium funiculosum*, *Scopulariopsis* sp., *Gliocladium fimbriatum*, *Curvularia maculans*, *Heterosporium allii*, *Nodulisporium* sp., and Mycelia Sterilia (1) are restricted to soils of 'A', while 6 species, *viz.*, *Rhizopus arrhizus*, *Phoma hibernica*, *Aspergillus niger* (strain 2), *Acrothecium* sp., *Dendryphion* sp., and Mycelia Sterilia (2) are confined to the soils of 'B'.

In all, 44 species of fungi, including 3 of Phycomycetes belonging to different genera, one member each of Ascomycetes and Sphaeropsidales, 35 of Moniliales spread over 16 genera and 4 forms of Mycelia Sterilia were isolated. Thus, while the Moniliales are well represented, the Phycomycetes, the

Ascomycetes and the Sphaeropsidales are fewer and the Melanconiales are altogether absent.

In soils of area 'A' *Aspergillus rugulosus* shows the highest percentage abundance. Next in order are *Aspergillus fumigatus* (strain 1), *A. niger* (strain 1), *Spondylocladium fumosum, Aspergillus flavus* and *A. japonicus.* In soils of area 'B' *Aspergillus rugulosus* has the highest percentage abundance followed by *A. fumigatus* (strian 1), *Spondylocladium fumosum, Aspergillus niger* (strain 1), *A. flavus* and *A. nidulans* (strain 2). The remaining fungi from both the areas have low abundance.

The highest percentage frequency in soils of 'A' is shown by *Aspergillus fumigatus* (strain 1) followed by *A. niger* (strain 1) *A. rugulosus, Spondylocladium fumosum, Aspergillus flavus* and *A. japonicus.* In soils of 'B', *Aspergillus fumigatus* (strain 1) having the highest frequency is followed by *A. niger* (strain 1), *A. rugulosus, A. flavus, Spondylocladium fumosum* and *Aspergillus nidulans* (strain 2). Other species show a restricted distribution.

Cunninghamella echinulata, Cladosporium sp., *Aspergillus nidulans* (strain 1), *A. fumigatus* (strain 2), *A. rugulosus, A. flavus, A. terreus* and *Spondylocaldium fumosum* show higher percentage frequency in soils of area 'B' than in soils of area 'A'. *Trichoderma koningi, Aspergillus fumigatus* (strain 2), *A. sydowi, A. japonicus, A. luchuensis, A. niger* (strain 1), *A. candidus, Curvularia lunata, Fusarium* spp., Mycelia Sterilia (3) and (4) are more frequent and abundant in soils of area 'A'. *Penicillium* spp. and *Fusarium* spp., are poorly represented in soils of 'B'.

Edaphic Factors in Relation to the Distribution of Fungi:

A perusal of table 2 and polygraphs brings out that the values of soil moisture, humus, water-holding capacity, organic carbon, nitrogen and C:N ratio in soils within the association (12·112%, 3·175%, 0·3005%, 0·0595% and 5·051, respectively) are higher than their values in soils without the association (9·970, 2·552%, 31·006%, 0·1407%, 0·0300% and 4·6889, respectively). Difference in pH is negligible, the values being 8·1 in soils of area 'A' and 8·2 in soils of area 'B'.

Higher values of soil moisture, humus, water-holding capacity, organic carbon, nitrogen and C:N ratio and lower values of pH have been found to favour the growth of microfungi (Waksman, 1927, Jensen 1931, Warcup 1951, Saksena 1955 & Chauhan 1960). In the present investigation, there is no marked difference between the total fungal population of areas 'A' and 'B'. On the other hand, the total number of species isolated is higher in 'A' (38) than in 'B' (31). This may be due to higher values of soil moisture, humus, water-holding capacity, organic carbon, nitrogen, and organic carbon nitrogen ratio in soils under 'A'. The difference in the fungal population (3·558) between the soils of the two areas is so small that the above factors appear to have little effect and the population is perhaps influenced more by the presence or absence of root exudates of the plants in the association (*Capparis decidua, Apluda mutica* and *Pergularia daemia*) or by the rhizosphere of all or any one of these plants.

SUMMARY

Soil microfungi and factors of the areas within and without *Capparis-Apluda-Pergularia* association have been worked out. The results show that, although the soil conditions in the two areas differ markedly, very little difference exists between the total fungal population of the two soils. At the same time, there is a great difference in the number of fungal types, frequency and abundance of individual fungi in soils of both areas. This, probably, is due to the fact that the microfungi in this case are being influenced less by edaphic factors and more by root exudates or rhizosphere of all or any one of the plants in the association.

ACKNOWLEDGEMENTS

The author wishes to express his deep sense of gratitude to Professor S. Sinha, Head of the Department of Botany, Agra College, Agra, for guidance and encouragement throughout the course of this investigation. He is thankful to Dr. K. M. M. Dakshini of Delhi University, Delhi, for suggesting the problem. Thanks are also due to the State Council of Scientific and Industrial Research, Uttar Pradesh, for the award of Scholarship.

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* Original not seen.

TABLE 1

Distribution, population, frequency and abundance of species of fungi isolated from soils within and outside the association.

S.N.	Name of species	Soils within the association			Soils outside the association		
		P	F	Ab.	P	F	Ab.
1.	*Rhizopus arrhizus* Fischer	...	...	...	0·262	1	×
2.	*Mucor hiemalis* Wehmer	0·140	1	×	...	...	...
3.	*Cunninghamella echinulata* Thaxter	1·678	2	1	2·227	2	1
4.	*Chaetomium globosum* Kunze	0·280	1	×	0·524	1	1
5.	*Phoma hibernica* Grimes, O'Connor & Cumins	...	...	...	0·131	1	×
6.	*Cephalosporium* sp.	0·420	1	×	1·179	1	1
7.	*Trichoderma koningi* Oudemans	1·818	1	1	0·131	1	×
8.	*T. lignorum* Harz	0·420	1	×	...	...	...
9.	*Aspergillus chevalieri* Thom & Church	0·420	1	×	...	...	...
10.	*A. fumigatus* Fres. (str. 1)	25·315	5	5	31·964	5	5
11.	*A. fumigatus* (str. 2)	0·699	1	1	0·262	1	×
12.	*A. fumigatus* (str. 3)	0·559	1	1	...	...	...
13.	*A. nidulans* (Eidam) Winter (str. 1)	0·979	1	1	1·179	1	1
14.	*A. nidulans* (str. 2)	1·818	1	1	3·144	2	1
15.	*A. variecolor* (Berk. & Br.) Thom & Raper	0·839	1	1	...	...	...
16.	*A. rugulosus* Thom & Raper	28·951	3	5	37·860	3	5
17.	*A. sydowii* (Bain. & Sart.) Thom & Church	0·699	1	1	0·655	1	1
18.	*A. flavus* Link	3·077	2	1	3·144	2	1
19.	*A. terreus* Thom	0·280	1	×	0·786	1	1
20.	*A. japonicus* Saito	2·937	2	1	1·441	1	1
21.	*A. luchensis* Inui	1·119	1	1	0·131	1	×
22.	*A. niger* van Tiegh. (str. 1)	8·951	4	3	6·026	3	2
23.	*A. niger* (str. 2)	...	...	...	0·393	1	×

(*Continued*)

TABLE 1 (*Contd.*)

Distribution, population, frequency and abundance of species of fungi isolated from soils within and outside the association.

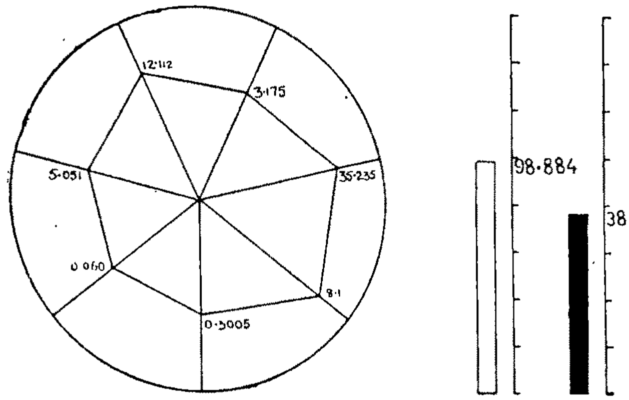
S.N.	Name of species	Soils within the association			Soils outside the association		
		P	F	Ab.	P	F	Ab.
24.	*A. sulphureus* (Fres.) Thom & Church	0·140	1	×	...	...	...
25.	*A. candidus* Link	0·599	1	1	0·262	1	×
26.	*Penicillium funiculosum* Thom	0 140	1	×	...	...	...
27.	*P. oxalicum* Thom	0·140	1	×	0·131	1	×
28.	*Scopulariopsis* sp.	0·140	1	×	...	...	...
29.	*Gliocladium fimbriatum* Gilman & Abbott	0·280	1	×	...	...	...
30.	*Spicaria divaricata* Gilman & Abbott	0·280	1	×	0·393	1	...
31.	*Nodulisporium* sp.	0·140	1	×	...	...	...
32.	*Stachybotrys atra* Corda	0·280	1	×	0·524	1	1
33.	*Curvularia lunata* (Wakker) Boedijn	1·119	2	1	0·131	1	×
34.	*C. maculans* (Bancroft) Boedijn	0·280	1	×	...	...	...
35.	*Heterosporium allii* Ellis & Martius	0·140	1	×	...	...	...
36.	*Spondylocladium fumosum* Martius	4.476	2	2	6·157	3	2
37.	*Acrothecium* sp.	...	...	...	0·393	1	×
38.	*Dendryphion* sp.	...	...	...	0·131	1	×
39.	*Alternaria tenius* Nees	1·399	1	1	1·179	2	1
40.	*Fusarium* spp.	3·497	2	2	0·131	1	×
41.	Mycelia Sterilia (dark) (1)	0·559	1	1	...	...	...
42.	,, ,, ,, (2)	...	...	...	0·[illegible]55	1	1
43.	,, ,, (white) (3)	2·098	1	1	0 392	1	1
44.	,, ,, ,, (4)	1·818	1	1	0·524	1	1
	Total	98·884	....	...	102·442	...	...

P=Population in thousands per gm., F=Frequency, Ab.=Abundance,
... indicates absence, × indicates abundance below 1%,
1,2,3,4,5 indicate frequency and abundance classes and str.=Strain.

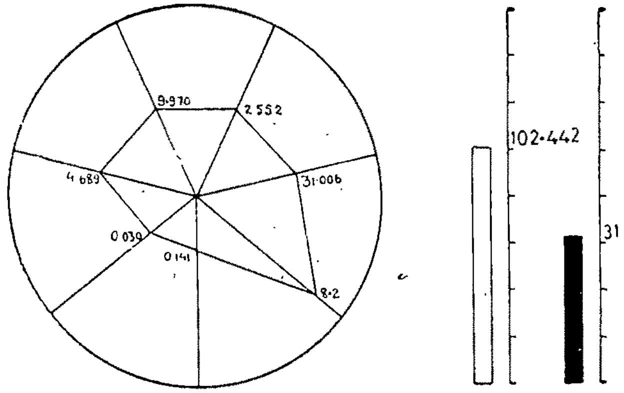
TABLE 2

Soil analysis data

S.N.	Soil factors	Soils within the association	Soils without the association
1.	Moisture	12·112%	09·970%
2.	Humus	03·175%	02·552%
3.	Water-holding capacity	35·235%	31·006%
4.	pH	8·1	8·2
5.	Organic carbon	00·3005%	00·1407%
6.	Nitrogen	00·0595%	00·0300%
7.	Organic C : N ratio	05·0510	04·6889



SOILS UNDER THE ASSOCIATION



SOILS AWAY FROM THE ASSOCIATION

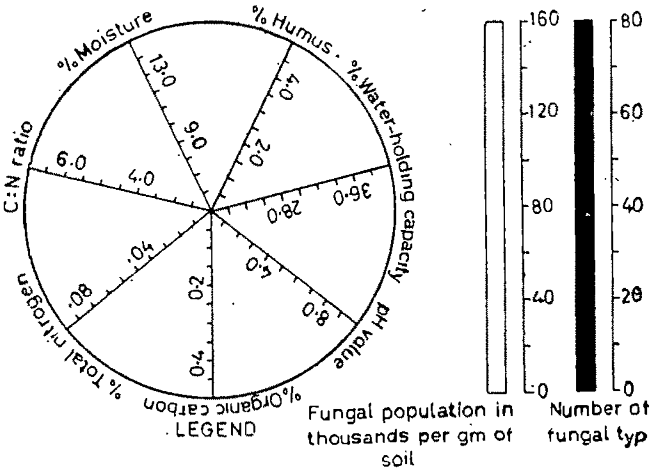


Fig. Polygraphs and histograms showing relationship of soil factors with fungal population and number of fungal types in areas within and without the association.

SAND CULTURE EXPERIMENT WITH *SHOREA ROBUSTA* SEEDLINGS[1,2]

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Very little work has been done in India on the mineral nutrition of forest tree species. Much of the work on nutrition is conducted at Oxford by Leyton (1952,54,55 and 56) on spruce, pine and larch. As almost no information is available on Indian forest species regarding nutrition, therefore, sand culture experiment on sal (*Shorea robusta*) seedlings was conducted to determine the nutritional balance of sal seedlings and for comparing the results with those obtained from the soil culture experiment described elsewhere. For the experiment the seedlings were raised and transplanted in the experimental pots. Two seedlings were transplanted in each pot they were as nearly equal in height as possible. Similarly the seedlings in various pots were also of nearly the same height. Great care was taken to wash away the sand particles adhering to the roots with distilled water before transplanting the seedlings in the experimental pots. The experimental pots were first washed and then painted with white paint on the inner surface to check the diffusion of salts etc., from the culture solutions of various treatments. They were properly numbered on the outer surface to represent the treatment and replication. Twenty pounds of pure silica sand was used as the substratum. Before filling in the pots, the sand was thoroughly washed and dried and its chemical composition was determined. It was ascertained that it did not contain nitrogen, potassium and phosphorous, the elements to be applied in various levels. This type of sand was found to be good enough for our purposes as we wanted to know the effect of these elements on the survival and growth of sal seedlings.

TABLE 1

Characteristics of sand used in the pots.

pH	Exchangeable Cao%	Exchangeable Mgo%	Silica %	Nitrogen %	K_2O%	P_2O_5%
6·9	0·64	0·031	97·9	..	..	..

DESIGN OF EXPERIMENT

Nitrogen, potassium and phosphorus were each applied at three levels *viz.*, O, 1 (first strength) and 4 (second strength). There were three replications of this complete factorial design, giving 81 experimental units (pots) in all.

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1. Part of the thesis approved by the Agra University.
2. Abstract read at the Indian Science Congress 1961.

TREATMENTS AND DETERMINATIONS

A basic doze of calcium, megnesium, sulphur and trace elements was given to every pot after three months interval. The levels of potassium, nitrogen and phosphorous were chosen corresponding to an application rate of 200 pounds per acre and 800 pounds per acre. The doses were given after three months interval, three times in all, during the year.

TABLE 2

Levels of Nitrogen, Potassium and Phosphorus Applied.

Salts used	Miligrams added per pot	
	Level 1	Level 4
1. Ammonium nitrate (NH_4NO_3)	2640	10560
2. Potassium chloride (Kcl)	2000	8000
3. Calcium phosphate ($Ca_3(PO_4)_2$)	4000	16000

Every treatment was replicated three times with two seedlings in each pot. Seedlings were transplanted after the establishment of seedlings in the sand. Every pot was watered on alternate days with 500 c. c. of distilled water. This amount of water was sufficient to wet the sand without seeping out of the pot. Thus any chance of the chemicals flowing out and being lost was eliminated; at the same time the nutrient solution was well dispersed in the sand and available to the roots of the seedlings. The following determinations were recorded in alternate months. Height growth (Cms.), number of leaves and leaf area (Cms.) and any other general feature such as deficiency symptoms.

The experiment was concluded after 1 year. The seedlings were then taken out of pots with their root system intact, thoroughly washed and separately dried in the oven and oven dried weights were recorded as follows. Total dry weight of seedlings (gms.), dry weight root (gms.) and dry weight shoot (gms.). The dry matter was then powdered and the following determinations were made from the plant powder, total ash%, nitrogen%, potassium% and phosphorus%. Standard methods were used for the chemical analysis. The data for all 27 treatment combinations were grouped in order of increasing values for : total dry weight, root weight, shoot weight, height increment and leaf area increment.

MORPHOLOGICAL EFFECTS

More or less specific changes in leaves were observed when there was a deficiency of different elements. A general change in leaf morphology was most strikingly apparent in the absence of nitrogen and potassium. The leaves showed stunting and yellowing in nitrogen deficient plants, whereas scorching of leaf margins were observed in potassium deficient plants. On the whole the deficiency symptoms were of the same type as in other plants reported by, for instance, Wallace (1951), Ingested (1957).

Deficiency symptoms attributable to all the three elements under investigation were visible in the leaves, atleast when the particular element was absent, and in some cases at low levels of nitrogen and potassium applications. The behaviour towards phosphorus could be adjudged only in its absence. In those cases where only one element was present in the nutrient solution, deficiency symptoms were appeared very early while in the presence of two elements they were a little delayed. Before any visible symptoms of nitrogen deficiency were noticed the growth of the seedlings was already retarded. Contrawise potassium deficiency symptoms appeared in plants with good growth.

It was also noticed that in those cases where nitrogen deficiency symptoms appeared in leaves, the roots of seedlings were rather thin and long. While in case of phosphorus deficiency the root tips were slightly blackish. In case of potassium deficiency the roots were also thin but not very long. In those pots in which potassium was given in higher doses the roots were thick and well formed and so was the case with phosphorus also.

TABLE 3

Plant Analysis and Treatment given.

Sl. No.	Treatment	Plant Analysis				Treatment given		
		Percentage Oven dry wt.				Percentage on wt. of sand used		
		K	P	N	Total Ash	K	P	N
1.	$K_2P_1N_2$	0·77	0·52	1·32	4·3	0·12	0·03	0·12
2.	$K_2P_2N_2$	0·74	0·57	1·28	4·4	0·12	0·12	0·12
3.	$K_1P_2N_2$	0·66	0·56	1·25	3·7	0·03	0·12	0·12
4.	$K_2P_2N_1$	0·71	0·60	0·18	4·1	0·12	0·12	0·03
5.	$K_1P_1N_2$	0·66	0·55	0·23	4·7	0·03	0·03	0·12
6.	$K_2P_1N_1$	0·71	0·55	1·20	5·7	0·12	0·02	0·03
7.	$K_1P_1N_1$	0·71	0·52	1·19	4·3	0·03	0·03	0·03

(*Continued*)

TABLE 3—(*Contd.*)

Plant Analysis and Treatment given.

Sl. No.	Treatment	Plant Analysis				Treatment given		
		Percentage Oven dry wt.				Percentage on wt. of sand used		
		K	P	N	Total Ash	K	P	N
8.	$K_1P_2N_1$	0·64	0·63	1·12	4·6	0·03	0·12	0·03
9.	$K_2P_0N_2$	0·62	0·30	0·86	4·6	0·12	0·00	0·12
10.	$K_0P_2N_2$	0·54	0·47	0·84	4·6	0·00	0·12	0·12
11.	$K_1P_0N_2$	0·59	0·29	0·81	3·4	0·03	0·00	0·12
12.	$K_0P_2N_1$	0·46	0·44	0·80	3·7	0·00	0·12	0·03
13.	$K_2P_0N_1$	0·61	0·28	0·84	4·1	0·12	0·00	0·03
14.	$K_0P_1N_2$	0·49	0·44	0·86	6·1	0·00	0·03	0·12
15.	$K_1P_0N_1$	0·56	0·28	0·74	3·3	0·03	0·00	0·03
16.	$K_2P_1N_0$	0·60	0·43	0·34	4·1	0·12	0·03	0·00
17.	$K_2P_2N_0$	0·61	0·51	0·31	5·9	0·12	0·12	0·00
18.	$K_0P_1N_1$	0·48	0·43	0·73	6·0	0·00	0·03	0·03
19.	$K_1P_2N_0$	0·53	0·50	0·33	3·9	0·03	0·12	0·00
20.	$K_1P_1N_0$	0·53	0·48	0·32	5·3	0·03	0·03	0·00
21.	$K_0P_1N_0$	0·41	0·36	0·31	4·8	0·00	0·03	0·00
22.	$K_2P_0N_0$	0·52	0·32	0·37	5·6	0·12	0·00	0·00
23.	$K_1P_0N_0$	0·50	0·32	0·34	3·8	0·03	0·00	0·00
24.	$K_0P_0N_2$	0·48	0·26	0·54	3·2	0·00	0·00	0·12
25.	$K_0P_2N_0$	0·47	0·43	0·30	5·5	0·00	0·12	0·00
26.	$K_0P_0N_1$	0·48	0·29	0·43	3·5	0·00	0·00	0·03
27.	$K_0P_0N_0$	0·28	0·25	0·28	2·04	0·00	0·00	0·00

TABLE 4

Basic Data.

Sl. No.	Treatment	Oven dry wt. (gms.)			Height (cms.)	Leaf area sq. cms.		
		Root	Shoot	Total	Increment	Initial	Final	Increment
1.	$K_2P_1N_2$	2·45	1·50	3·96	6·63	34·7	72·3	37·6
2.	$K_2P_2N_2$	2·43	1·31	3·36	6·13	32·4	70·1	37·7
3.	$K_1P_2N_2$	1·98	1·26	3·24	5·72	28·5	65·9	37·4
4.	$K_2P_2N_1$	1·96	1·11	3·07	4·90	30·9	66·3	35·4
5.	$K_1P_1N_2$	1·86	1·05	2·91	4·20	31·7	68·0	36·3
6.	$K_2P_1N_1$	1·79	0·97	2·75	3·40	25·0	56·4	31·4
7.	$K_1P_1N_1$	1·67	0·86	2·53	3·17	27·0	52·8	35·8
8.	$K_1P_2N_1$	1·69	0·86	2·54	3·10	25·8	50·2	24·4
9.	$K_2P_0N_2$	1·59	0·70	2·29	1·92	28·3	43·7	15·4
10.	$K_0P_2N_2$	1·55	0·68	2·23	2·12	30·9	28·3	–2·6
11.	$K_1P_0N_2$	1·53	0·66	2·29	2·30	27·4	41·6	14·2
12.	$K_0P_2N_1$	1·54	0·67	2·21	1·93	27·0	26·7	–0·3
13.	$K_2P_0N_1$	1·54	0·66	2·20	2.07	33·7	35·0	1·3
14.	$K_0P_1N_2$	1·56	0·61	2·17	1·67	27·3	37·6	10·3
15.	$K_1P_0N_1$	1·49	0·64	2·13	2·23	27·7	38·0	10·3
16.	$K_2P_1N_0$	1·49	0·61	2·11	2·28	27·6	36·5	8·9
17.	$K_2P_2N_0$	1·46	0·62	2·08	1·95	18·0	23·3	5·3
18.	$K_0P_1N_1$	1·43	0·60	2·03	2·03	30·6	27·8	–2·8
19.	$K_1P_2N_0$	1·43	0·60	2·03	2·00	28·4	27·6	–0·8
20.	$K_1P_0N_0$	1·27	0·58	1·85	2·40	34·6	42·3	7·7
21.	$K_0P_0N_0$	1·47	0·54	2·00	1·63	31·8	34·7	2·9
22.	$K_2P_0N_0$	1·40	0·55	1·94	1·55	36·9	36·2	–2·7

(Continued)

TABLE 4—(*Contd.*)

Basic Data.

Sl. No.	Treatment	Oven dry wt. (gms.)			Height (cms.) Increment	Leaf area sq. cms.		
		Root	Shoot	Total		Initial	Final	Increment
23.	$K_1P_0N_0$	1·33	0·54	1·87	1·62	30·4	34·7	4·3
24.	$K_0P_0N_2$	1·39	0·46	1·85	1·63	33·5	37·5	4·0
25.	$K_0P_2N_0$	1·30	0·54	1·84	1·59	33·2	30·2	–2·0
26.	$K_0P_0N_1$	1·31	0·43	1·74	1·13	33·5	37·0	3·5
27.	$K_0P_0N_0$	0·63	0·30	0·98	0·95	28·3	21·7	–6·6

DISCUSSION AND CONCLUSIONS

All treatment combinations in which all the three elements (N, K and P) were persent showed considerably better growth than other treatment combinations, deficient in one or more factors. The best growth was shown by the treatment $K_2P_1N_2$. On the whole it seems that higher doses of potassium and nitrogen (0·12%) enhance growth of sal seedlings. The higher levels of nitrogen also helps in better assimilation of potassium and vice versa. Phosphorus, on the other hand, seems to be required in lesser quantity, as it produced better response at lower (0·03%) level. The higher level of phosphorus at the same time retards the assimilation of both nitrogen and potassium. Phosphorus at the lower level (0·03%) showed sufficiently good growth in most of the combinations (provided nitrogen and potassium were present in higher doses). With increase in phosphorus dose the growth becomes poorer if nitrogen and potassium were present at the lower levels, as in the case with $K_1P_2N_1$ combination which produced considerably poorer growth than $K_2P_1N_2$ and even poorer growth than $K_1P_1N_1$ treatment.

Therefore it can be assumed that the minimum threshold value of phosphorus is very near about 0·03% (provided nitrogen and potassium were in optimum amount). But if either potassium or nitrogen is low than a higher dose of phosphorus is required. With increase in the availability of nitrogen and potassium the growth increases irrespective of phosphorus (provided it is present in optimum amount). Both these elements produced comparatively poorer growth if present at the lower concentrations as in the case of $K_1P_2N_2$ or $K_2P_2N_1$ treatments which resulted in lower responses compared to $K_2P_1N_2$ treatment. Treatment $K_1P_1N_1$ is too much inferior to $K_2P_1N_2$ and if the concentration of potassium or nitrogen is increased, enhanced growth follows as in the case of $K_2P_1N_1$ and $K_1P_1N_2$ treatments. Therefore, it can be assumed that the minimum threshold for potassium and nitrogen is somewhere near to 0·12%. The minimum threshold for nitrogen is slightly more than potassium, as with increase of nitrogen from $K_1P_1N_1$ to $K_1P_1N_2$ better growth results contrary to what happens when potassium is increased to $K_2P_1N_1$.

SUMMARY

To precisely determine the nutritional balance and mineral requirements of sal seedlings sand culture experiment was conducted with regard to nitrogen, potassium and phosphorus. These elements were applied at 3 levels 0, 0·3% and 0·12%) in single, double and triple, *i.e.*, all possible factorial combination.

It, therefore, follows that a higher supply of nitrogen is conducive to better growth and it acts best if potassium is also high. If these two factors are at a high level phosphorus is needed in small quantities only. If any of these two factors is at a low level then a higher quantity of phosphorus may produce a slight improvement.

Not only does each element exert a significant influence on the growth of the seedlings but the presence of each component has a profound influence on the effect exerted by the others. The significance of the interactions shows that the effect of each element is modified to a varying degree by the presence of the others.

ACKNOWLEDGEMENTS

My grateful thanks are due to Shri S. K. Seth, Head, Division of Forestry, Forest Research Institute, Dehra Dun, for guidance and necessary help, to the Scientific Research Committee, U. P., for the scholarship for the above study.

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Fig. 1

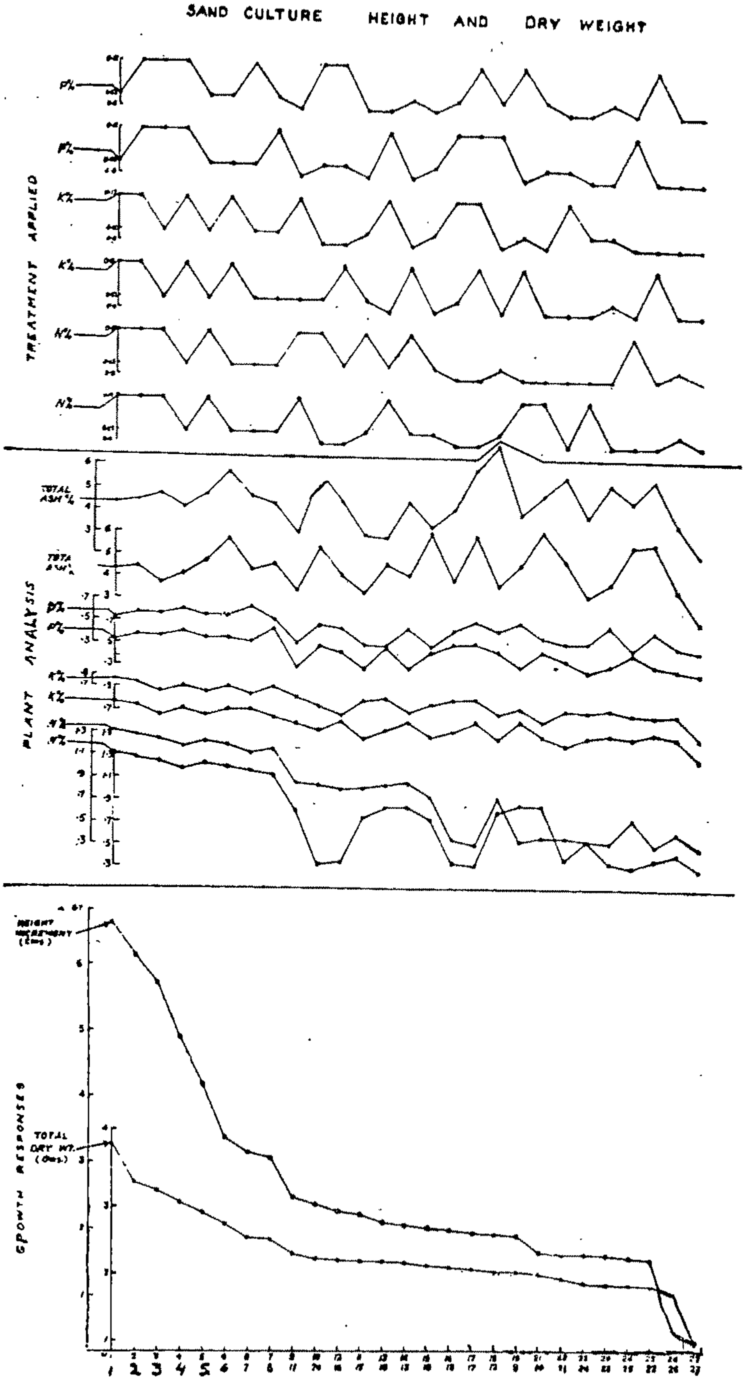
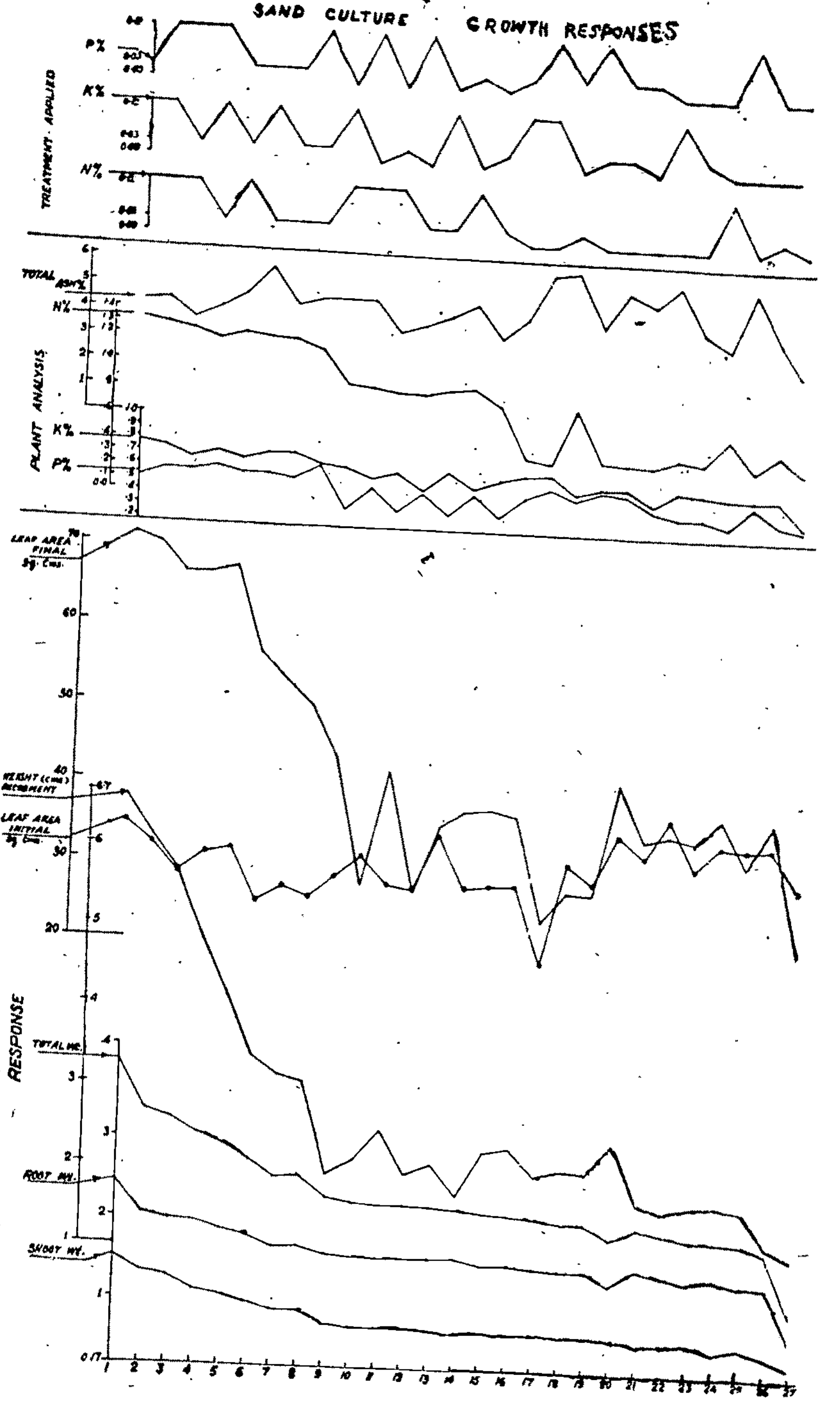

SAND CULTURE HEIGHT AND DRY WEIGHT
TREATMENT APPLIED
P%
P%
K%
K%
N%
N%
PLANT ANALYSIS
TOTAL ASH %
TOTAL ASH %
P%
P%
K%
K%
N%
N%
GROWTH RESPONSES
HEIGHT INCREMENT (Cms)
TOTAL DRY WT. (Gms)
1
2
3
4
5
6
7
8

Fig. 2


SAND CULTURE GROWTH RESPONSES
TREATMENT APPLIED
P%
K%
N%
PLANT ANALYSIS
TOTAL ASH%
N%
K%
P%
LEAF AREA FINAL Sq. Cms.
HEIGHT (cms) INCREMENT
LEAF AREA INITIAL Sq. Cms.
RESPONSE
TOTAL WT.
ROOT WT.
SHOOT WT.
70
60
50
40
30
20
1
2
3
4
5
6
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POTENTIAL FUNGICIDAL COMPOUNDS. PART V—SOME HALOGENONITROPHENYL ESTERS OF N, N-DIBENZYL AND PYRROLIDINO DITHIOCARBAMIC ACIDS

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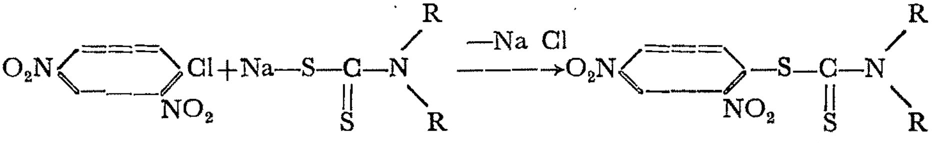
Polynitrophenyl esters of a number of N-substituted dithiocarbamic acids have recently been found to possess fungicidal activity against a wide range of fungi, particularly, *Tricophyton mentagrophytos, Aspergillus niger* and *Microsporum canis*[1]. They are also used as accelarators in rubber vulcanisation[2,3]. In view of the wide range of fungicidal activity of these compounds and their use in industry, the work[1,4,5] is now extended to the synthesis of a few nitrophenyl esters of N, N-dibenzyl and pyrrolidino-dithiocarbamic acids and to make a systematic study of their fungicidal and insecticidal properties.

These esters (III) have been obtained by the condensation of polynitrohalogenobenzenes (I) with sodium salt of N-substituted dithiocarbamic acid (II) in ethanolic or methanolic solution at 0°-5°C. The reaction takes place with the elimination of a molecule of sodium chloride.



(I) (II) (III)

Thus 1-chloro-2:4-dinitro-, 1-chloro-2:6-dinitro, 1:2 dichloro-4:6-dinitro, 1-chloro-2-bromo-4:6-dinitro-, 1:3-dichloro-4:6-dinitro-, 1:4-dicloro-2:6-dinitro-, 1-chloro-2-methyl-4:6-dinitro-, 1-chloro-3-methyl-4:6-dinitro-, 1-chloro-4-methyl-2:6-dinitro-, 1-chloro-2:4:6-trinitro-3-methyl-, 1:2:3-trichloro-4 : 6-dinitro-, and 1 : 3.dichloro-2-methyl-4 : 6-dinitro-benzenes gave 2:4-dinitro-, 2:6-dinitro-, 6-chloro-2:4-dinitro-, 6-bromo-2:4-dinitro-, 5-chloro-2:4dinitro-, 4-chloro-2:6-dinitro-, 6-methyl-2:4-dinitro-, 5-methyl-2:4-dinitro-, 4-methyl-2:6-dinitro-, 5-methyl-2:4:6-trinitro-, 5:6-dichloro-2:4-dinitro-and 5-chloro-6-methyl-2:4-dinitro-phenyl esters of N,N-dibenzyl (Table 1) and pyrrolidino-dithiocarbamic acid (Table 2) when condensed with their sodium salts respectively.

Structures of the esters obtained from 1:2:5-trihalogeno-4:6-dinitrobenzene, which has two mobile halogen atoms (in position 1 and 5) is based on the previous observation[1] that it is the halogen atom at position-1 which takes part in the condensation. Thus 1:2:5-trichloro-(or 2:5-dichloro-1-bromo-)-4:6-dinitro-benzene gave 3:6-dichloro-2:4-dinitrophenyl esters of

N,N-dibenzyl and pyrrolidino-dithiocarbamic acids when condensed with their sodium salts respectively.

EXPERIMENTAL

Halogenonitrophenyl esters of N-substituted dithiocarbamic acids:

Halogenonitrophenyl esters of N,N-dibenzyl- and pyrrolidino dithiocarbamic acids have been obtained by the condensation of halogenopolynitrobenzenes with sodium salts of N,N-dibenzyl- and pyrrolidino dithiocarbamic acids respectively in ethanolic solutions at 0°-5° by the method used earlier[1],[4].

All esters obtained are yellow crystalline compounds insoluble in water and soluble in acetone. They are sparingly soluble in ethanol and methanol. Their melting points and other characteristics are described in tables 1 and 2.

The fungicidal and insecticidal activity of these esters is under investigation.

ACKNOWLEDGEMENTS

The authors are thankful to Meerut College authorities for providing necessary facilities and to the State Council of Scientific and Industrial Research (U.P.) for a contingent g ant to one of them (S.P.G.)

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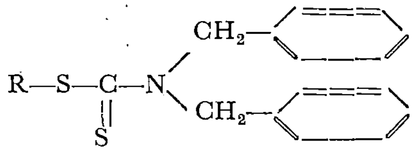
TABLE 1

Polynitrophenyl esters of N, N-dibenzyl dithiocarbamic acid.

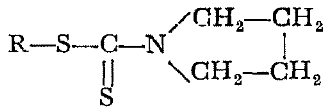


S.No.	Reactive halogeno-benzene used	R	M.P.* °C	Yield	Formula	%Nitrogen		%Sulphur	
						Found	Reqd.	Found	Reqd.
1.	1-chloro-2:4-dinitro-	2:4-dinitrophenyl	115	80	$C_{21}H_{17}O_4N_3S_2$	9·58	9·56	14·60	14·57
2.	1-chloro-2:6-dinitro-	2:6-dinitrophenyl	112	75	$C_{21}H_{17}O_4N_3S_2$	9·55	9·56	14·62	14·57
3.	1:2 dichloro-4:6-dinitro	6-chloro-2:4-dinitrophenyl	144	76	$C_{21}H_{16}O_4N_3S_2Cl$	8·85	8·87	13·58	13·51
4.	1-chloro-2-bromo-4:6-dinitro-	6-bromo-2:4-dinitrophenyl	175	70	$C_{21}H_{16}O_4N_3S_2Br.$	7·99	8·10	12·40	12·35
5.	1:3-dichloro-4:6-dinitro-	5-chloro-2:4-dinitrophenyl	70	80	$C_{21}H_{16}O_4N_3S_2Cl$	8·80	8·87	13·51	13·51
6.	1:4-dichloro-2:6-dinitro-	4-chloro-2:6-dinitrophenyl	106	80	$C_{21}H_{16}O_4N_3S_2Cl$	8·84	8·87	13·49	13·51
7.	1-chloro-2-methyl-4:6-dinitro-	6-methyl-2:4-dinitrophenyl	120	65	$C_{22}H_{19}O_4N_3S_2$	9·24	9·27	14·21	14·12
8.	1-chloro-3-methyl-4:6-dinitro-	5-methyl-2:4-dinitrophenyl	131	70	$C_{22}H_{19}O_4N_3S_2$	9·29	9·27	14·18	14·12
9.	1-chloro-4-methyl-2:6-dinitro-	4-methyl-2:6-dinitrophenyl	128	75	$C_{22}H_{19}O_4N_3S_2$	9·25	9·27	14·15	14·12
10.	1-chloro-3-methyl-2:4:6-trinitro-	5-methyl-2:4:6-trinitrophenyl	100	80	$C_{22}H_{18}O_6N_4S_2$	11·22	11·24	12·89	12·85
11.	1:2:3-trichloro-4:6-dinitro-	5:6-dichloro-2:4-dinitrophenyl	95	85	$C_{21}H_{15}O_4N_3S_2Cl_2$	8·29	8·26	12·64	12·59
12.	1:2:5-trichloro-4:6-dinitro-	3:6-dichloro-2:4-dinitrophenyl	85	75	$C_{21}H_{15}O_4N_3S_2Cl_2$	8·21	8·26	12·62	12·59
13.	2:5-dichloro-1-bromo-4:6-dinitro-	—do—	85	78	$C_{21}H_{15}O_4N_3S_2Cl_2$	8·25	8·26	12·66	12·59
14.	1:3-dichloro-2-methyl-4:6-dinitro-	5-chloro-6-methyl-2:4-dinitrophenyl	132	70	$C_{22}H_{18}O_4N_3S_2Cl$	8·60	8·61	13·21	13·13

*All melting points are uncorrected.

TABLE 2

Polynitrophenyl esters of pyrrolidinodithiocarbamic acid.



Sl. No.	Reactive halogeno-benzene used	R	M. P.* °C	Yield	Formula	% Nitrogen		% Sulphur	
						Found	Reqd.	Found	Reqd.
1.	1-chloro-2:4-dinitro-	2:4-dinitrophenyl	136	75	$C_{11}H_{11}O_4N_3S_2$	13·41	13·42	20·51	20·45
2.	1-chloro-2:6-dinitro-	2:6-dinitrophenyl	120	72	$C_{11}H_{11}O_4N_3S_2$	13·44	13·42	20·55	20·45
3.	1:2-dichloro-4:6-dinitro-	6-chloro-2:4 dinitrophenyl	138	70	$C_{11}H_{10}O_4N_3S_2Cl$	12·12	12·09	18·50	18·42
4.	1-chloro-2-bromo-4:6-dinitro-	6-bromo-2:4-dinitrophenyl	220	70	$C_{11}H_{10}O_4N_3S_2Br$	10·69	10·71	16·30	16·32
5.	1:3-dichloro-4:6-dinitro-	5-chloro-2:4-dinitrophenyl	140	75	$C_{11}H_{10}O_4N_3S_2Cl$	12·06	12·09	18·49	18·42
6.	1:4-dichloro-2:6-dinitro-	4-chloro-2:6-dinitrophenyl	120	80	$C_{11}H_{10}O_4N_3S_2Cl$	12·05	12·09	18·44	18·42
7.	1-chloro-2-methyl-4:6-dinitro-	6-methyl-2:4-dinitrophenyl	173	60	$C_{12}H_{13}O_4N_3S_2$	12·86	12·84	19·62	19·57
8.	1-chloro-3-methyl-4:6-dinitro-	5-methyl 2:4-dinitrophenyl	137	65	$C_{12}H_{13}O_4N_3S_2$	12·81	12·84	19·63	19·57
9.	1-chloro-4-methyl-2:6-dinitro-	4-methyl-2:6-dinitrophenyl	134	68	$C_{12}H_{13}O_4N_3S_2$	12·83	12·84	19·55	19·57
10.	1-chloro-3-methyl-2:4:6-trinitro-	5-methyl-2:4:6-trinitrophenyl	110	75	$C_{12}H_{12}O_6N_4S_2$	15·61	15·05	17·28	17·21
11.	1:2:3-dichloro-4:6-dinitro-	5:6-dichloro-2:4-dinitrophenyl	118	70	$C_{11}H_9O_4N_3S_2Cl_2$	10·97	10·99	16·79	16·75
12.	1:2:5-dichloro-4:6-dinitro-	3:6-dichloro-2:4-dinitrophenyl	75	65	$C_{11}H_9O_4N_3S_2Cl_2$	10·98	10·99	16·76	16·75
13.	2:5-dichloro-1-bromo-4:6-dinitro-	-do-	75	70	$C_{11}H_9O_4N_3S_2Cl_2$	10·94	10·99	16·80	16·75
14.	1:3 dichloro-2-methyl-4:6-dinitro-	5-chloro-6-methyl-2:4-dinitrophenyl	123	80	$C_{12}H_{12}O_4N_3S_2Cl$	11·63	11·61	17·76	17·70

*All melting points are uncorrected.

KINETICS OF OXIDATION OF ISO-PROPYL ALCOHOL BY POTASSIUM PERSULPHATE

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Chemical Laboratories, Th. D. S. B. Govt. College, Naini Tal, India.

ABSTRACT

The uncatalysed and the Ag^+ catalysed isopropyl alcohol— $K_2S_2O_8$ reaction are unimolecular. In uncatalysed reaction, both in buffered and in non-buffered media, the rate constant increases with increase in $K_2S_2O_8$ concentration at lower concentration and becomes constant after a certain concentration is reached. In Ag^+ catalysed reaction, the rate constant decreases with increase in $K_2S_2O_8$ concentration and after a certain stage becomes approximately constant. The unimolecular rate constant in Ag^+ catalysed reaction decreases slightly with time, this has been traced to the increase in H^+ ion concentration as the reaction proceeds; it increases with increase in isopropyl alcohol concentration upto a certain limit after which it remains approximately constant. The rate is a linear function of $AgNO_3$ concentration. The temperature coefficient, energy of activation, frequency factor and entropy of activation for the Ag^+ catalysed reaction within the temperature range of 30° —45°C., are 2·15, 14·51 K cals; $9{\cdot}334 \times 10^5$ litre mol. sec^{-1} and 31·32 E.S.U., respectively. The salt effect is negative and of the primary exponential type.

INTRODUCTION

During a systematic study of the kinetics of oxidation of ketones[1],[2] and aldehydes[3],[4],[5] by persulphate ion it was considered necessary by us to investigate the kinetics of oxidation of simple aliphatic alcohols. Levitt and Malinowski[6],[7] have recently studied the kinetics of the uncatalysed oxidation of isopropyl alcohol by $K_2S_2O_8$ in buffered medium and found it to be of first order with respect to S_2O_8'', and of zero order with respect to isopropyl alcohol at 0·05 M or higher concentrations but at lower concentrations the order approached unity. Further, within the range of 0·00125 to 0·06M $K_2S_2O_8$ concentrations the rate constant increased with an increase in the initial concentration of $K_2S_2O_8$ but at higher concentrations a limiting value was reached. We have studied the kinetics of the Ag^+ catalysed oxidation of isopropyl alcohol by $K_2S_2O_8$ in order to determine the existence of the aforesaid peculiarities in the reaction.

EXPERIMENTAL

The experimental technique and procedure followed was the same as adopted in previous studies (loc. cit.) Isopropyl alcohol G. R., E. Merck, recrystallised G. R., E. Merck $K_2S_2O_8$ and other reagents either of G. R.,

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E. Merck or of A. R., B. D.H. quality were used. In the reaction in buffered medium the reaction mixture was added to 10 ml. of 0·1 N HCl to neutralise the alkali before the persulphate content was estimated by iodometric method.

The phosphate buffer used in the study of the uncatalysed reaction was of the same composition as that employed by Levitt and Malinowski (loc. cit.). The Ag^+ catalysed reaction could not be carried out in phosphate buffer medium because silver nitrate reacts with phosphate.

Results of measurements—The graphs of log $[S_2O_8'']$ against time for experiments in absence of and in presence of a small concentration of $AgNO_3$ are shown in fig. 1; their linear nature shows that both the uncatalysed and the Ag^+ catalysed reaction are unimolecular. Further, they show that the catalysed reaction is faster than the uncatalysed one, and in both cases there is a break, the curves after the break are linear but their slope is much less. The later behaviour is more pronounced in the uncatalysed reaction and approximately corresponds to the stage where the whole of the isopropyl alcohol has been oxidised. The curve after the break, according to Levitt and Malinowski, is for the oxidation of acetone. This is supported by the fact that the rate constants for the Ag^+ catalysed oxidation of acetone by $K_2S_2O_8$ under the same condition (curve III, fig. 1) and for the later part of the curve II, are nearly the same, $2{\cdot}8210 \times 10^{-3}$ and $2{\cdot}8291 \times 10^{-3}$, respectively.

1. *Eeffect of $K_2S_2O_8$ concentration*—The results obtained in the study of reaction with six different initial concentrations of $K_2S_2O_8$ from 0·005 to 0·03 M. and the same concentrations of iso-propyl alcohol and $AgNO_3$ are shown graphically in fig. 2. The value of the unimolecular constant (k) evaluated from these curves are recorded in table 1.

TABLE 1

Iso-propyl alcohol = 0·02 M; $AgNO_3$ = 0·0003 M;
Temperature = 35°C

Concentration of $K_2S_2O_8$	0·005M	0·010M	0·015M	0·020M	0·025M	0·030M
$k \times 10^3$	6·3332	3·4545	3·1404	2·4600	2·2506	2·1991

The above data show that the rate constant decreases with an increase in $K_2S_2O_8$ concentration and that the decrease at high concentration is much less than that at lower concentrations. It may be mentioned here that the rate constant decreases slightly with time in any particular run also. Thus the effect of $K_2S_2O_8$ concentration for the Ag^+ catalysed reaction is contrary to that found by Levitt and Malinowski (loc. cit.) for the uncatalysed reaction in buffered medium which we have independently verified. The observed results may be due to large negative salt effect in the Ag^+ catalysed reaction or to the specific inhibitory effect of K^+ ion or both.

Experiments conducted with increasing $K_2S_2O_8$ concentration in presence of high ionic strength, obtained by adding an excess of K_2SO_4 to the reaction mixture, as shown in table 2, also show a decrease in the rate constant with an increase in $K_2S_2O_8$ concentration, although it is slightly less at higher than at lower concentrations. These data thus rule out the possibility of the decrease in the rate constant with increase in $K_2S_2O_8$ concentration due to the negative salt effect only.

TABLE 2

Iso-propyl alcohol $= 0{\cdot}02$ *M*; $K_2SO_4 = 0{\cdot}16$ *M*,
$AgNO_3 = 0{\cdot}0003$ *M*; *Temperature* $= 35°C$

Time in minutes	$K_2S_2O_8$ $=0{\cdot}005M$ $k \times 10^3$ (Uni.)	$K_2S_2O_8$ $=0{\cdot}01M$ $k \times 10^3$ (Uni.)	$K_2S_2O_8$ $=0{\cdot}015M$ $k \times 10^3$ (Uni.)	$K_2S_2O_8$ $=0{\cdot}02M$ $k \times 10^3$ (Uni.)	$K_2S_2O_8$ $=0{\cdot}025M$ $k \times 10^3$ (Uni.)	$K_2S_2O_8$ $=0{\cdot}03M$ $k \times 10^3$ (Uni.)
2	...	...	...	...	...	...
15	4·6768	3·2596	...	...	...	...
30	4·4826	2·9037	2·4181	2·2655	1·8095	1·8424
60	3·9826	2·7040	2·1481	1·8344	1·7153	1·5524
90	3·6477	2·5071	2·0910	1·7508	1·6199	1·4891
120	3·6430	2·4236	2·0200	1·7487	1·5555	1·4774
150	3·6630	2·3854	1·9387	1·6489	1·5421	1·4549
180	3·4997	2·2993	1·9430	1·6250	1·5202	1·4115
210	...	...	1·9021	1·6099	1·4925	1·4006
240	3·3567	2·2323	1·8733	1·5649	1·4892	1·3908

2. *Salt effect*—This effect on the catalysed reaction was determined by using K_2SO_4 of varying salt concentration. The results obtained are given in table 3.

TABLE 3

Iso-propyl alcohol $=K_2S_2O_8=0{\cdot}02$ *M*; $AgNO_3=0{\cdot}0004$ *M*; *Temperature* $=35°C$

Concentration of K_2SO_4	μ	$k \times 10^3$
0·00 M	0·06	2·9823
0·01 M	0·09	2·7175
0·02 M	0·12	2·6024
0·04 M	0·18	2·4642
0·06 M	0·24	2·2914

On plotting $(\mu)^{\frac{1}{2}}$ against log k a linear curve is obtained, showing that the negative salt effect is of the primary exponential type.

3. *Effect of* H^+ *ion*—It will be seen from table 2 that the rate constant decreases with the progress of the reaction. Considering that this effect is due to an increase in H^+ ion, the reaction between isopropyl alcohol and $K_2S_2O_8$ was conducted without any addition and in presence of (i) H_2SO_4, (ii) high concentration of K_2SO_4, (iii) high concentration of K_2SO_4 and H_2SO_4. The results obtained, tabulated below, bear out the aforesaid assumption that the effect due to an increase in ionic strength is comparatively small.

TABLE 4

Iso-propyl alcohol $=K_2S_2O_8=0{\cdot}01$ *M*; $AgNO_3=0{\cdot}0004$ *M*; *Temperature* $=35°C$

Time in minutes	Expt. I $k \times 10^3$ (Uni.)	Expt. II H_2SO_4 $=0{\cdot}01M$ $k \times 10^3$ (Uni.)	Expt. III K_2SO_4 $=0{\cdot}1$ M $k \times 10^3$ (Uni.)	Expt. IV K_2SO_4 $=0{\cdot}1$ M H_2SO_4 $=0{\cdot}04$ M $k \times 10^3$ (Uni.)
2	...	...	...	...
30	3·9397	3·2406	2·7389	1·2660
60	3·6689	3·2559	2·2037	1·1674
90	3·5827	3·2683	2·0622	1·1279
120	3·3374	3·2595	1·9809	1·1222
150	3·3231	3·1495	1·8844	1·1048
180	3·2811	3·1103	1·8256	1·1010
210	3·2740	3·0909	1·8158	1·1116
240	3·2580	3·0916	1·7882	1·1068

4. *Effect of iso-propyl alcohol concentration*—Uncatalysed and Ag^+ catalysed reactions were studied at different alcohol concentrations in the same buffered medium (in case of uncatalysed reaction) as employed by Levitt and Malinowski (loc. cit.). In the former case, the results were similar to those obtained by previous workers. The results for the catalysed reaction, given in table 5, are similar to those for the uncatalysed reaction, the rate constant increasing with increasing concentration of the alcohol, upto a certain limit beyond which it becomes constant. Since the reaction at 0.08 M alcohol and 0.01 M $K_2S_2O_8$ concentrations is also unimolecular, it shows that the order of the reaction with respect to S_2O_8'' ion is one and, therefore, the reaction with respect to alcohol is of zero order.

TABLE 5

$K_2S_2O_8=0{\cdot}01$ *M*, $AgNO_3=0{\cdot}0003$ *M*; *Temperature—35°C*

Conc. of iso. pro. alcohol	0.01M	0·02M	0·03M	0·04M	0·05M	0·06M	0·08M
$k \times 10^3$ (evaluated graphically)	2·8079	3·3128	3·6677	4·5772	7·1963	7·3228	7·1678

Effect of $AgNO_3$—Reactions conducted with different concentrations of $AgNO_3$ have revealed that the rate constant increases on increasing the concentration of $AgNO_3$, the relation between the two being linear *i. e.*, $\frac{dx}{dt}\, \alpha\, C_{Ag^+}$.

5. *Effect of temperature*—Reactions were also carried out at different temperatures from 30° to 45°C., and the results obtained were utilised to calculate (i) the temperature coefficient (ii) energy of activation, (iii) frequency factor and (iv) entropy of activation. The calculated values are given in table 6.

TABLE 6

Iso-propyl alcohol$=K_2S_2O_8=0{\cdot}02$ *M*; $AgNO_3=0{\cdot}0004$ *M*

Temperature	$k \times 10^3$ (Univ.) (graphically)	Temp. coeff.	Energy of activation E K cals.	Frequency factor litre mol. $sec.^{-1}$	Entropy of activation $\Delta s \neq$ E.S.U.
30°C.	1·9149	2·20	14·64	$9{\cdot}003 \times 10^5$	—31·34
35°C.	2·9823			$9{\cdot}400 \times 10^5$	—31·32
40°C.	4·2375	2·10	14·38	$9{\cdot}371 \times 10^5$	—31·33
45°C.	6·2411			$9{\cdot}565 \times 10^5$	—31·32
Mean		2·15	14·51	9·334	—31·32

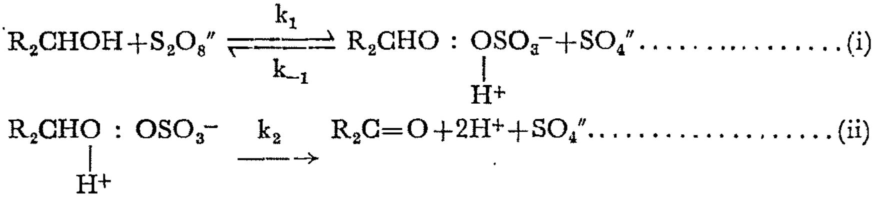
DISCUSSION

Thus we find that the Ag^+ catalysed reacticn between $K_2S_2O_8$ and isopropyl alcohol is unimolecular, being probably cf first order with respect to S_2O_8'' ion and of zero order with respect to alcchol. It exhibits a negative exponential salt effect which shows that the rate determining step is the reaction between two oppositely charged ions. Further we have shown in our previous study[8] that the product obtained in this reaction is acetone.

To account for the dependence of the rate constant on the concentration of $K_2S_2O_8$ and alcohol in the uncatalysed reaction, Levitt and Malinowski (loc.cit.) have proposed the following equation —

$$-\frac{dp}{dt}=k_cP=k_{max}\left[\frac{A_cP_o}{(b+A_o.(C+P_o)}\right]P$$

where k_c is the corrected rate constant, k_{max} is the maximum or limiting rate constant b is an emperical constant. A_o is the initial alcohol concentration and P_o and P are the concentrations of persulphate initially and at time t. The following mechanism has been proposed by these workers—



$$R_2CHOH+S_2O_8'' \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} R_2CHO:\underset{\substack{|\\ H^+}}{O}SO_3^-+SO_4''\ldots\ldots\ldots\ldots\ldots(i)$$

$$R_2CH\underset{\substack{|\\ H^+}}{O}:OSO_3^- \xrightarrow{k_2} R_2C=O+2H^++SO_4''\ldots\ldots\ldots\ldots\ldots\ldots(ii)$$

This has been shown to be incorrect by Wilberg[9] who used tracer technique. Also a direct reaction between persulphate and alcohol has been ruled out previously by the allyl acetate experiments of Kolthoff and coworkers[10].

Our observations on the Ag^+ catalysed reaction, can be explained by the following mechanism :—

$$Ag^++S_2O_8'' \xrightarrow[\text{determining}]{\text{rate}} Ag^{++}+SO_4''+SO_4' \qquad (i)$$

$$SO_4'+H_2O \xrightarrow{\text{rapid}} OH+HSO_4' \qquad (iia)$$

$$OH+Ag^{++} \xrightarrow{\text{rapid}} Ag^++OH^+ \qquad (iib)$$

$$OH^++R_2CHOH \xrightarrow{\text{more rapid}} R_2COH+OH+H^+ \qquad (iic)$$

$$OH+R_2CHOH \xrightarrow{\text{rapid}} R_2COH+H_2O \qquad (iid)$$

$$SO_4'+R_2CHOH \xrightarrow{\text{rapid}} R_2COH+HSO_4' \qquad (iie)$$

$$R_2COH+S_2O_8'' \xrightarrow{\text{rapid}} R_2C=O+HSO_4'+SO_4' \qquad (iii)$$

$$R_2COH+SO_4' \xrightarrow{\text{rapid}} R_2C=O+HSO_4' \qquad (iv)$$

This mechanism explains the unimolecularity of the reaction with respect to S_2O_8'' ion, linear dependence of rate on $AgNO_3$ concentration and independence of the rate of alcohol concentration. The decrease in rate constant values with time in a particular run has been shown to be due to increase in H^+ ion concentration as the reaction proceeds. However, it has not been, so far, possible to clearly account for the dependence of the rate constant on alcohol or persulphate concentration. An expression similar to the one, suggested by Levitt et al., may be correct but a theoretical explanation for the same is not possible on the basis of the existing data. Hence further work is being carried out to determine the exact cause of the variation of rate constant with persulphate or alcohol concentration in the case of Ag^+ catalysed reaction and thereby the exact mechanism of the process.

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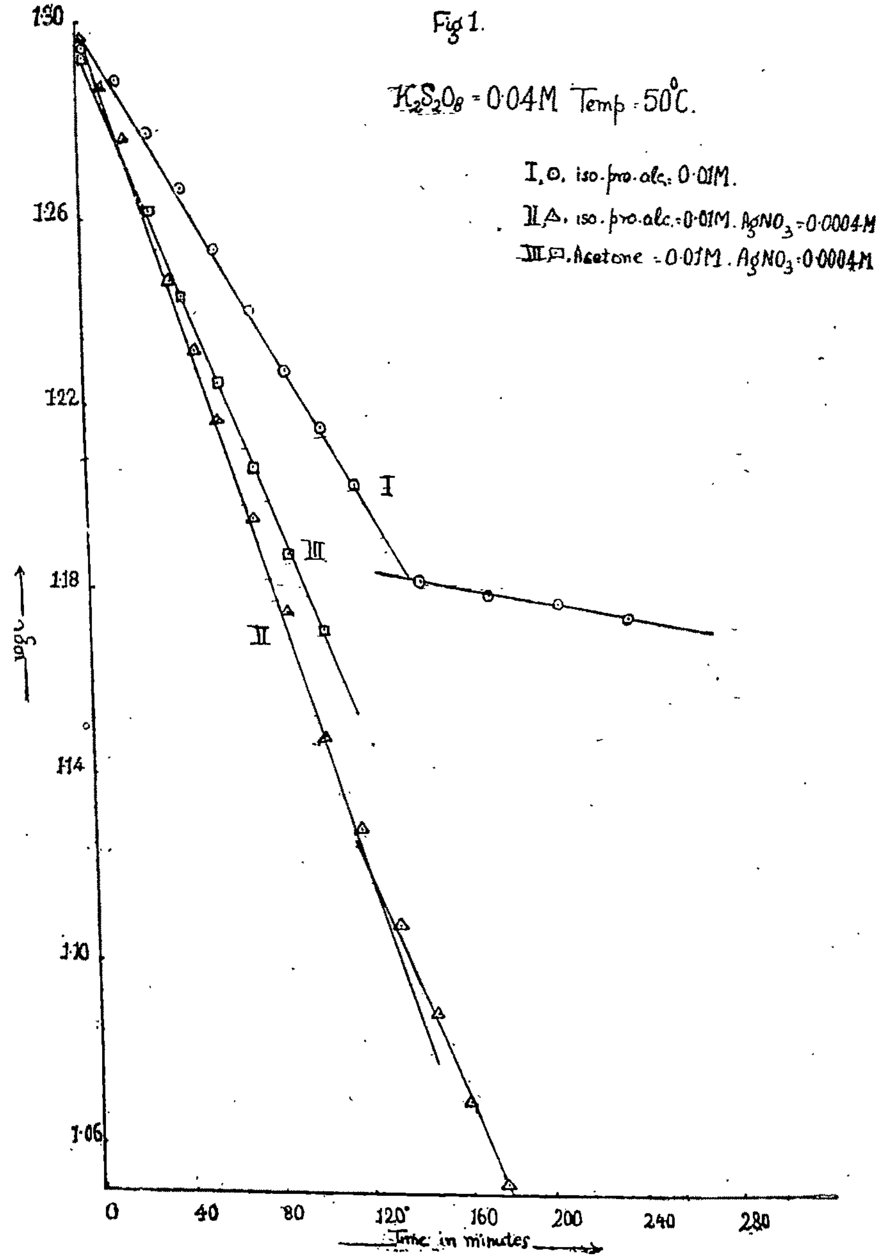

Fig 1.

K₂S₂O₈ = 0·04M Temp = 50°C.
I, ⊙, iso-pro-alc. 0·01M.
II, △, iso-pro-alc. = 0·01M. AgNO₃ = 0·0004M
III, ⊡, Acetone = 0·01M. AgNO₃ = 0·0004M
1·30
1·26
1·22
1·18
1·14
1·10
1·06
log c
I
II
III
0
40
80
120
160
200
240
280
Time in minutes

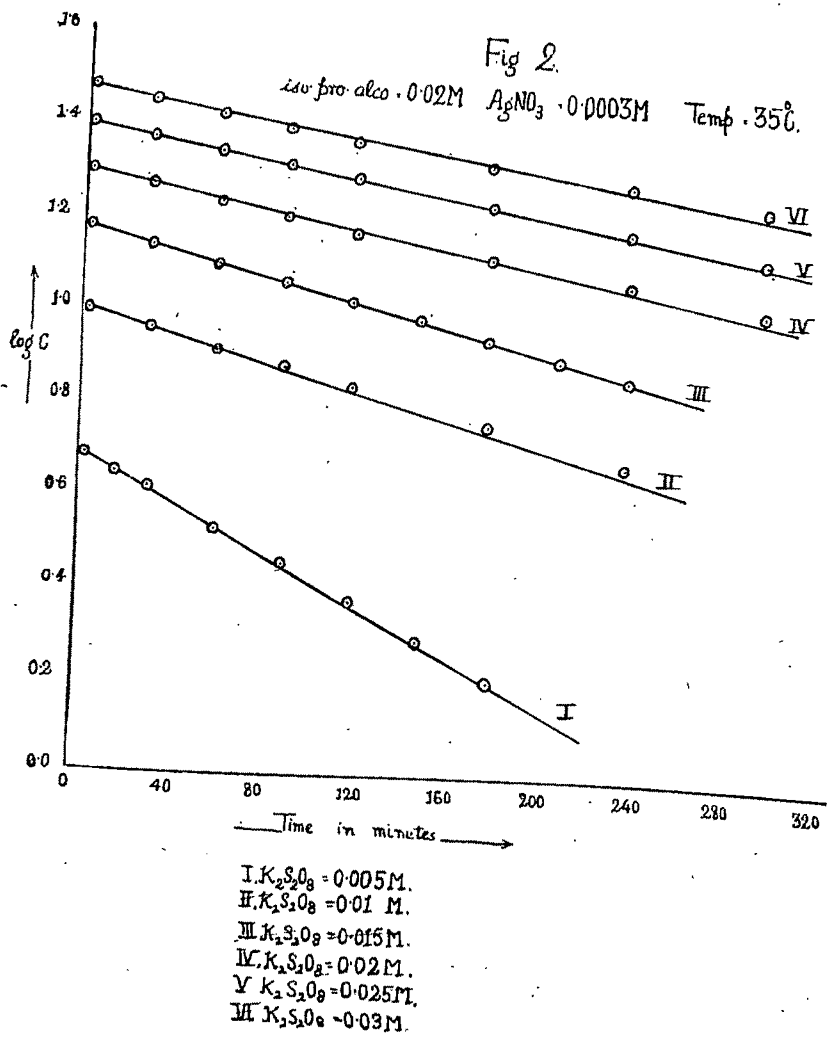
Fig 2.
iso pro alco · 0·02M AgNO3 · 0·0003M Temp · 35°C.
1·6
1·4
1·2
1·0
0·8
0·6
0·4
0·2
0·0
log C
0
40
80
120
160
200
240
280
320
Time in minutes
VI
V
IV
III
II
I
I. K2S2O8 = 0·005M.
II. K2S2O8 = 0·01 M.
III. K2S2O8 = 0·015M.
IV. K2S2O8 = 0·02M.
V K2S2O8 = 0·025M.
VI K2S2O8 = 0·03M.

ON THE EARWIG, *HYPURGUS HUMERALIS*, KIRBY ITS GENITALIA AND OPISTHOMERES

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The following study is mainly a redescription of *Hypurgus humeralis*, Kirby of which the existing account is not adequate for its distinct singularity from other recently-described forms. The present description is largely based on material collected for the first time from Madhya Pradesh, India, on light by the author in the month of September and October 1964.

Hypurgus humeralis, Kirby

Hypurgus humeralis, Kirby was first described in 1891 by W.F. Kirby under the name *Opisthocosmia humeralis*. Later on, Burr (1910) redescribed it and gave it the name *Hypurgus humeralis*, Kirby, and on the basis of certain external features, he placed it in the sub-family *Opisthocosminae* of the family *Forficulidae*. Since the Burr's description (1910), considerable advances have been made in the taxonomy of Forficuline group. To place the species correctly among its allies, a complete and more detailed information of genitalia and opisthomeres introduced by Verhoeff (1902), Zacher (1911) and Burr (1915a and 1915b) is required. Burr (1915a) and (1911), on the basis of the study of genitalia, placed it under the sub-family *Forficulinae* of the family *Forficulidae*. Material from Burma (Hincks, 1947a), while quite distinct from that examined by Kirby (1891), agrees well with the description of *H. humeralis* than does Burr's (1910) material. It is, therefore, necessary to publish a detailed description of genitalia and opisthomeres of *Hypurgus humeralis* to ascertain its position.

The original authors described *H. humeralis* with cerci arched gently inwards to form a sharp tooth on the inner margin in male, a description supported by Hincks (1947a). But the present collection from Madhya Pradesh clearly shows that the forceps in male are straight and slightly hooked at the apex with crenulate inner margin (Fig. 1).

Genitalia (Fig. 2)

The genitalia is a typical forficuline type. The metaparameres (Mpm) are gently curved inwards, without any chitinous structure, somewhat elongated with rounded apex and equal breadth throughout their length except the extreme apex and the base. They are about 0·48 mm long and 0·12 mm wide. The metaparameres are connected to the large and flattened proparameres (Ppm) by a clear hinge. The space between the two metaparameres is occupied by the median unpaired penis lobe (Preputial Sac), permanently directed forwards with its long characteristic virga The preputial sac (P.S.) arises from the basal part of the proparameres. The virga (Vg) is internally strengthened by chitinous lining and is about 1·3 mm long and 0·04 mm wide in the middle. Thus it is about two and a half times as long as the metaparameres. The articulation of reniform basal vesicle (B. ves.) has a characteristic rounded chitinous plate and is provided with chitinous armature (C. arm.) and short ejaculatory duct (Ej. d.) at its posterior end. The vesicle is about 0·13 mm long and 0·05 mm wide in the middle.

Opisthomeres (Fig. 3a, b)

The opisthomeres of *Hypurgus humeralis*, Kirby are peculiar as they possess all the three clearly demarcated segments. In male the pygidium (Pg) is one and a half times longer than broad and is about double as long as the metapygidium and telson combined. It is somewhat capsular in shape with broad base and narrow apex. The pygidium is provided with a group of lateral spines (Sp). The metapygidium (Mpg) is closely fitted with the pygidium so that both the segments look like a single structure. It is roughly triangular with proximal base fitted with pygidium and the narrower distal concave apex with two bulgings on either side within telson. The third segment, the telson (Te), telescoped with the metapygidium, surrounds it completely except the base. The telson looks like a funnel with broad mesially elevated cap-like apex bearing spines and broad basal tube surrounding the metapygidium. Telson is a delicate structure not chitinized like metapygidium.

In female the opisthomeres are smaller than those of male having similar general outline. The pygidium (Pg) is capsular with broad deeply constricted base and with lateral spines (Sp). It is a little longer than broad and about one and a half times longer than metapygidium and telson combined. The metapygidium (Mpg) and Telson (Te) are quite different from those of male. The metapygidium is fused with the pygidium as in male and is cone-like with apex bearing a faint membranous cap having spines. The telson with broad flat apex surrounds the metapygidium.

DISCUSSION

The present studies support very great possibility of placing *Hypurgus humeralis*, Kirby under sub-family Forficulinae. The opisthomeres, so far neglected by taxonomists, are of very great taxonomic value, specially in the Forficuline forms, where according to Hincks (1947b) the genitalia are very confusing. The relationships between various forms of *Forficulinae* are mainly indicated by the first few segments of antennae, pronotum, the markings of the elytra and wingtips and shape of the forceps by former systematics. The relationships, mainly based on these grounds, appear at first to be unwarranted. The author (1965) pointed out that the shape and abnormal lengths of the forceps can not be regarded as specific in separating the species.

However, in searching for the true basic relationships between different forms, it is essential to seek those characters which arise from fundamental biological processes and developments. General similarity of these external characters is often not sufficient evidence upon which fundamental relationships may be based. Thus, instead of genitalia the study of opisthomeres is of great taxonomic value in the earwigs, specially in the Forficuline forms. The opisthomeres of *Hypurgus humeralis*, Kirby are small but well developed with all the clearly defined three segments and not very much reduced (Burr, 1915b). Almost complete union of pygidium and metapygidium (the rudiments of the eleventh and twelfth segments respectively) into a single chitinized unit in the *Hypurgus humeralis*, Kirby make for greater functional efficiency in the insect. The mechanical stability afforded by such unified structure in insects may be of considerable advantage to them. This is endorsed by the present studies of opisthomeres and agrees with Verhoeff's (1902) formula for Forficuline forms and with Burr's (1915a) and Hincks (1947a) views regarding systematic position of *Hypurgus humeralis*, Kirby.

The modern systematics can not neglect opisthomeres in Forficuline earwigs for establishing their relationships together with genitalia.

SUMMARY

1. The *Hypurgus humeralis*, Kirby has been described as a new record from Madhya Pradesh.
2. The variation in its male forceps has been described for the first time.
3. The microscopic structure of the male genitalia has been discussed in detail.
4. The author has thrown flood of light on the opisthomeres of *Hypurgus humeralis*, Kirby, and their importance with the genitalia in the determination of taxonomic position of earwigs, specially Forficuline forms.

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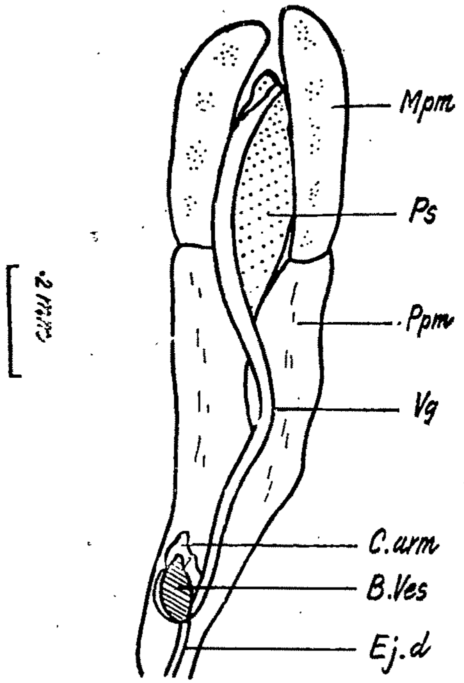

Fig. 2

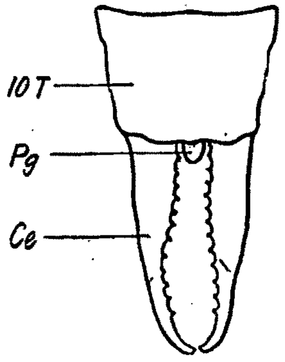

Fig. 1

Fig. 1. The cerci of male in dorsal view.
Fig. 2. The male genitalia.

Abbreviations

B. ves—Basal vesicle; C. arm—Chitinous armature; Ce—Cercus; Ej. d—Ejaculatory duct; Mpm—Metaparamere; P. S.—Preputial Sac; Pg—Pygidium; Ppm—Proparamere T—Tergum; Vg—Virga.

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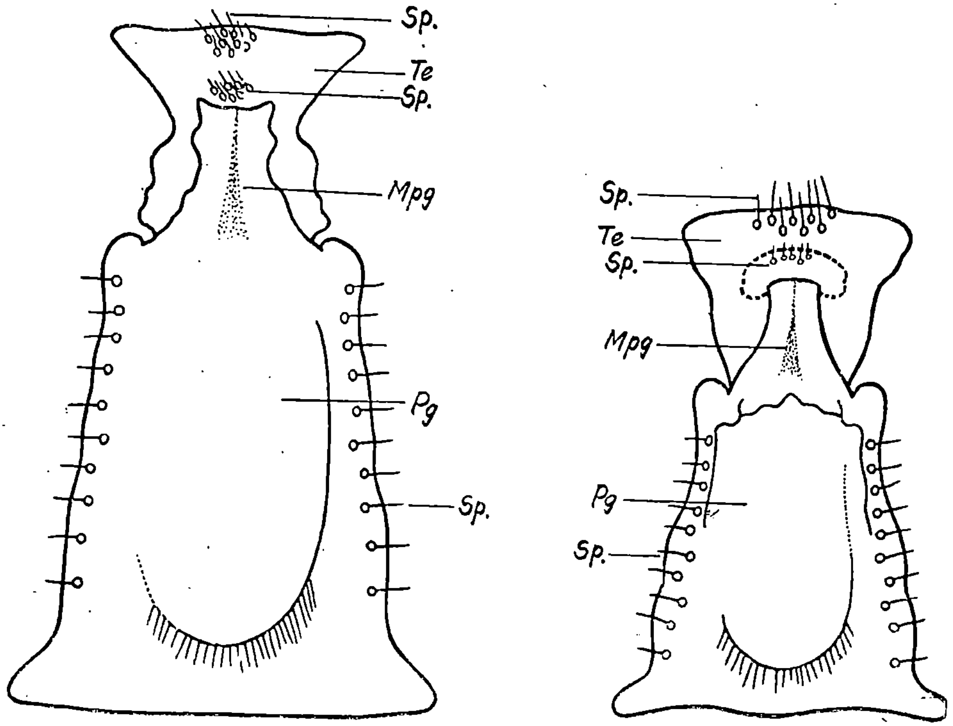
* Not consulted in original.



MALE
Fig. 3a

FEMALE
Fig. 3b

Fig. 3. (a) Male opisthomeres.
(b) Female opisthomeres.

Abbreviations

Mpg—Metapygidium; Pg—Pygidium; Sp—Spine; Te—Telson.

Abstract of Theses

CHEMICAL EXAMINATION OF (1) A FIXED OIL FROM THE SEEDS OF *XANTHIUM STRUMARIUM* (*ADHASISI*) AND (2) THE ESSENTIAL OIL FROM AJOWAN SEEDS*

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PART I

Xanthium strumarium (*Adhasisi*) is an agricultural weed widely distributed throughout hotter parts of India. The fruit consists of a hard thorny shell containing oil-bearing kernels. The kernels were separated by the author from the fruits by soaking them in dilute sulphuric acid. The optimum conditions for the satisfactory treatment are to dip the fruits in 1 per cent solution of sulphuric acid (by volume) for 48 hours and then drying in the sun for about a week, when the outer thorny shell of the fruits becomes brittle and can be crushed easily to give out the kernels.

The semi-drying oil obtained from the kernels, contains unsaturated and saturated fatty acids. The former consisted of 23 per cent of oleic acid and 67 per cent of linoleic acid; the percentages of these acids determined by chemical and spectroscopic methods are slightly higher than those reported by earlier workers.[1,2,3] The constituent saturated acids were found to be palmitic, stearic and behenic acids by the use of paper chromatography[4] and also by forming urea complexes and separating them by liquid-solid counter-current distribution method.[5] The presence of the first two acids has been reported by previous workers but the existence of the third one has been shown for the first time by the author. The author's work has also shown the absence of saturated fatty acids from C_{10} to C_{14} in the oil, reported previously.[3]

The solvent extracted fixed oil was found to possess jelly-forming property which is not due to any component acid in the oil; also no unsaturated hydroxy acid was found in the oil. Further it was observed that oxidation and polymerisation were found to take place rapidly in the case of solvent extracted oil, caused probably by the catalytic effect of some material extracted in traces along with the oil from the kernels.

PART II

Trachyspermum ammi or *Ptychotis ajowan* is grown in various parts of India specially Malwa, Central India, Rajasthan and Southern India. The seeds give 3 to 4 per cent essential oil on steam distillation. This oil contains thymol as the chief constituent along with another phenol carvacrol which is an isomer of thymol. The residual oil after removal of phenols constituting nearly 45 per cent of the oil is known as thymene.

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* Abstract of the thesis submitted to Agra University for the degree of Doctor of Philosophy.

The constituents of thymene were separated by fractional distillation using a Towers' column with batch-strip still-head. p-Cymene and γ-terpinene were found to be the main constituents of the oil, the former being about 55 per cent and the latter nearly 35 per cent. Other components of the oil were found by the author to be d-α-pinene (1·5%), d-β-pinene (3%) and dipentene (5%). Out of the above the presence of d-β-pinene has been established for the first time whereas the other four have been reported previously[6,7] though the percentages differed to a great extent. γ-Terpinene which has been reported previously as a minor component forms 35 per cent of the oil. The presence of β-pinene and the approximate percentages of various constituents as reported by the author have been confirmed by subsequent work of Nigam *et al.*,[8] who with the help of gas chromatography and infra-red spectroscopy have established the presence of all the constituents as reported by the author along with camphene, myrcene and Δ^3-carene, which are present in traces.

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EFFECT OF PHYSICAL AGENTS ON THE CHEMICAL ACTIVITIES OF LIVING SYSTEMS*

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This thesis presents studies on the action of the ultraviolet, ultrasonics and ultracentrifugation on growth, RNA and DNA synthesis and certain oxidative activities, in *Vibrio cholerae.*

ACTION OF ULTRAVIOLET RADIATION

Experiments on the determination of ultraviolet radio-sensitive sites in the bacterial cell revealed growth and nucleic acid syntheses to be more susceptible to lower doses of radiation as compared to oxidative activities, which were affected only at higher radiation doses. Further DNA synthesis was found to be more sensitive than RNA synthesis or growth in both the strains of *V. cholerae.* Inhibition of DNA synthesis was seen to be immediate whereas a considerable increase in growth and RNA synthesis was noted without any increase in formation of DNA during the early stages. Although DNA synthesis indicated a recovery in the later period, lysis was simultaneously observed which was confirmed by microscopic examination. In one of the strains (Ogawa 60) this lysis was seen to be associated with the depolymerisation of DNA and RNA. That the ultraviolet interferes with the cell multiplication was evident from the greater population of abnormally elongated cells in the irradiated cultures. The abnormally long cells were, however, found to be unstable and lysed out readily. Cysteine, when added prior to irradiation almost completely prevented the ultraviolet damage on growth and RNA, DNA synthesis. Its subsequent addition, however, failed to bring about any protection both when the irradiation was carried out in cold or at room temperature.

Marked susceptibility of the nucleic acid synthesis to ultraviolet was further investigated by studying the incorporation of P^{32} labelled orthophoshate and of adenine -8-C^{14} in different cellular fractions of growing and non-growing cultures. In the latter case it was found that uptake of P^{32} was inhibited by copper ions, and other respiratory poisons like sodium azide and 2,4 dinitrophenol, whereas this incorporation was almost insensitive to ultraviolet (at higher doses only partial inhibition was observed). These findings reveal that incorporation of phosphate in non-growing cells may represent macromolecular 'turnover' which is relatively insensitive to ultraviolet radiations as compared to their synthesis in growing cultures.

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* Abstract of the thesis submitted to the Agra University for the degree of Doctor of Philosophy.

In order to find out inter-relationship if any, between growth and nucleic acid synthesis in this organism, effect of chloramphenicol and certain purine pyrimidine analogues was investigated. Chloramphenicol could bring about an inhibition of both growth and nucleic acid synthesis, particularly of DNA, in the non-irradiated cultures and further blocked the resumption of DNA synthesis in irradiated cells. Inspite of these inhibitory effects, chloramphenicol was seen to prevent ultraviolet induced lysis. Protection of ultraviolet induced lysis was also given by 6-azauracil, which again markedly brought about an inhibition of both DNA and RNA synthesis in normal culture. 6-azathymine and 8-azaguanine did not show any significant effect on the nucleic acid synthesis and further failed to protect lysis in the irradiated cultures. The inhibitory effects of 6-azauracil and protective effect on lysis was found to be reversed by uracil but not by thymine.

Oxidative activities involved in the Krebs' cycle were observed to be inhibited at higher doses of ultraviolet and the extent of inhibition varied with the substrate and was also seen to be increased with the time of incubation. These findings would probably indicate that the preformed enzymes may not be damaged by ultraviolet action.

Pyruvate and fumarate activities were found to be comparatively more sensitive than glucose oxidation under the same conditions. Enzymes involved in the oxidation of α-Ketoglutorate, succinate and malate, although were more sensitive than glucose oxidative enzymes, they were less significantly affected as compared to pyruvate or fumarate. The sensitivity in oxidation of amino acids namely alanine, aspartic and glutamic acid, were found to be comparable to their corresponding keto-acids. Endogenous respiration even at higher dosages was markedly insensitive to ultraviolet. Lower doses which induce the formation of abnormally long cells did not inhibit oxidation of fumarate or pyruvate in such cultures indicating thereby that ultraviolet perhaps does not specifically interfere with the synthesis of these enzymes in growing cells.

Chemical substances like thiourea, xanthine, ascorbic acid, and thiosulphate were able to protect the ultraviolet inhibition of pyruvate oxidation, when added prior to irradiation.

ACTION OF ULTRASONICS

The effect of lower ultrasonics exposures was studied on the oxidation of Krebs' cycle substrates, on catalase and on RNA depolymerase of *V. cholerae*. The oxidative activities were not only inactivated by ultrasonic treatment but were also affected by a milder treatment of cell disruption as in a Mickle's disintegrator. The oxidation of malate, fumarate or pyruvate was more sensitive than succinic oxidase which is known to be particulate in nature. Cytochrome oxidase was observed to be still less vulnerable to ultrasonic treatment. Complex oxidative activities would thus be seen to be more susceptible to ultrasonic action.

In contrast to other oxidative activities catalase activity was not affected by cell disruption in Mickle's disintegrator, although it was partially inactivated by ultrasonic treatment. Further, RNA depolymerising activity reported to be detectable only after cell disruption, was markedly activated by ultrasonic treatment and showed continued increase even after complete lysis of cells.

EFFECT OF ULTRACENTRIFUGATION

A significant decrease in endogenous respiration of *V. cholerae* cells and also in their ability to oxidise glucose was observed after centrifugation at high speeds; the effect although noticeable even when the cells were resuspended in the supernatant, was further enhanced when they were suspended in a fresh medium (normal saline). These results suggest leakage of some vital factors, involved in the oxidative mechanisms, into the supernatant by centrifugation. However, growth (turbidity increase) and nucleic acid biosynthesis did not seem to be significantly influenced by similar high speed centrifugation. Moreover, in contrast to observations in *V. cholerae* no inhibition of endogenous respiration of glucose oxidation occurred in *Saccharomyces cerevisiae,* when the cells were resuspended in the original supernatant; and a slight decrease only in endogenous respiration was noted when they were suspended in fresh saline.

KINETIC STUDY OF THE OXIDATION REACTIONS OF PERSULPHATE ION AND OTHER PERSALTS*

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The investigation deals with the kinetic study of the oxidation of mercurous and stannous ions by persulphate ion. Besides this, the study of the Sn^{++} —S_2O_8'' reaction has led to a new volumetric method for the estimation of tin (II) which is more accurate and easy in manipulation than the existing methods. The results obtained with different reactions are summarised here.

$Hg_2(NO_3)_2$-$K_2S_2O_8$ *reaction—uncatalysed:*

The uncatalysed oxidation of $Hg_2(NO_3)_2$ by potassium persulphate in dilute HNO_3 solution is a slow unimolecular reaction, first order with respect to persulphate and zero order with respect to mercurous ions, and is attended with an induction period, the extent of which increases with increasing concentration of mercurous nitrate and decreases with an increasing concentration of persulphate. Further, it is characterised by a very high temperature coefficient (3·1685). HNO_3 has no appreciable effect on the rate while the reaction is appreciably catalysed by Ag^+ ion.

$Hg_2(NO_3)_2$—$K_2S_2O_8$ *reaction—Ag^+ catalysed:*

The Ag^+ catalysed reaction is similar in behaviour to the uncatalysed reaction, in respect of both the over-all order and the induction period. However, the rate constant values decrease with an increase in the initial concentration of $K_2S_2O_8$, due to the specific inhibitory effect of K^+ ions. The induction period decreases very considerably when $Hg_2(NO_3)_2$ solution free from HNO_2 is employed, suggesting that it is due to HNO_2 present in $Hg_2(NO_3)_2$ in traces. The temperature coefficient for the reaction is much lower (1·86) than for the uncatalysed reation.

$Hg_2(NO_3)_2$—$K_2S_2O_8$ *reaction—solid compound formation:*

It was found that a precipitate is obtained during the oxidation of mercurous nitrate by potassium persulphate in nitric acid medium. At low concentration of nitric acid, the product separating out initially is white $HgSO_4$ which changes to lemon yellow basic salt $HgSO_4.2HgO$ on standing. At high concentration (0·96 N) of HNO_3, the precipitate is white Hg_2SO_4, due to the precipitation of Hg_2^{++} by SO_4'' formed by the reduction of $K_2S_2O_8$, the mercuric sulphate being soluble at this concentration of HNO_3. On increasing the concentration of $Hg_2(NO_3)_2$, the lemon yellow precipitate becomes contaminated with white Hg_2SO_4. These conclusions have been confirmed by qualitative and quantitative analysis of the precipitates, and the study of the physical nature of, and the effects of washing and of light and heat on the precipitates.

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$Hg_2(ClO_4)_2$—$K_2S_2O_8$ reaction—uncatalysed and catalysed:

The reaction between $Hg_2(ClO_4)_2$ in perchloric acid medium and $K_2S_2O_8$ shows no induction period, but a very large induction period appears when even a trace of nitrite ($3{\cdot}0 \times 10^{-5}$ M) is present. Excepting that the reaction is much faster than with $Hg_2(NO_3)_2$ under similar conditions, it is similar to the latter as far as the over-all order, order with respect to each of the reactants and the catalytic action of Ag^+ ion are concerned, the temperature coefficients of the uncatalysed and catalysed reactions being 3·360 and 1·352, respectively.

Temperature coefficient, energy of activation, frequency factor and entropy of activation for the Hg_2^{++} —S_2O_8'' reaction:

The values of temperature coefficient, energy of activation and entropy of activation for the uncatalysed and the Ag^+ catalysed reactions are markedly different but are of the same order whether $Hg_2(NO_3)_2$ or $Hg_2(ClO_4)_2$ is used as the reductant; hence it has been concluded that the mechanisms for the two reactions are also different. The mechanism suggested for the uncatalysed reaction is as follows :

$$S_2O_8'' \xrightarrow{k_1} 2\,SO_4' \qquad (i) \text{ initial step}$$

$$SO_4' + H_2O \xrightarrow{k_2} HSO_4' + OH \qquad (ii)$$

$$OH + Hg_2^{++} \xrightarrow{k_3} Hg^{++} + Hg^{+} + OH' \qquad (iii)$$

$$S_2O_8'' + Hg^{+} \xrightarrow{k_4} Hg^{++} + SO_4'' + SO_4' \qquad (iv)$$

$$SO_4' + Hg^{+} \xrightarrow{k_5} Hg^{++} + SO_4'' \qquad (v)$$

Reactions (*i*) and (*ii*) are the same as supposed by Bartlett and Cotman[1] and by Kolthoff and Miller[2] in the thermal decomposition of potassium persulphate in aqueous solution. These lead to the kinetic expression :

$$\frac{-d[S_2O_8'']}{dt} = \frac{-d[Hg_2^{++}]}{dt} = \{k_1 + k_4[Hg^+]\}\,[S_2O_8''] = k_0[S_2O_8''], \text{ since } [Hg^+]$$

is constant, and accounts for the general characteristics of the reaction.

The probable mechanism suggested for the Ag^+ catalysed reaction is as follows and is on the lines of the general mechanism for Ag^+ catalysed reactions suggested by Srivastava and Ghosh[3] :—

$$Ag^+ + S_2O_8'' \xrightarrow[\text{determining}]{\text{rate}} Ag^{++} + SO_4'' + SO_4' \qquad (1)$$

$$SO_4' + H_2O \xrightarrow{\text{rapid}} HSO_4' + OH \qquad (2)$$

$$OH + Ag^{++} \xrightarrow{\text{rapid}} Ag^{+} + OH^{+} \qquad (3)$$

$$OH + Hg_2^{++} \xrightarrow{\text{rapid}} OH' + 2Hg^{++} \qquad (4)$$

$$OH + Hg_2^{++} \xrightarrow{\text{rapid}} OH' + Hg^{++} + Hg^{+} \qquad (5)$$

$$Hg^{+} + S_2O_8'' \xrightarrow{\text{rapid}} Hg^{++} + SO_4'' + SO_4' \qquad (6)$$

$$Hg^{+} + SO_4' \xrightarrow{\text{rapid}} Hg^{++} + SO_4'' \qquad (7)$$

The specific inhibitory effect of different ions on the uncatalysed $Hg_2(ClO_4)_2-K_2S_2O_8$ reaction was found to be in the order

$$Mn^{++} \gg Hg^{++} > K^{+} > Na^{+} > Zn^{++} \approx Mg^{++} \approx CH_3COO' \approx NO_3'.$$

Since Mn^{++} is known to react with S_2O_8'', the high inhibitory effect of Mn^{++} is surprising. A detailed study of the kinetics of $Hg_2^{++}-S_2O_8''$ reaction in presence of $MnSO_4$—both uncatalysed and Ag^{+} catalysed—has revealed that the inhibitory effect of $MnSO_4$ is very high in the case of Ag^{+} catalysed reaction and it increases with increase in $AgNO_3$ concentration upto a certain limit and then decreases. This has led to the conclusion that the inhibitory effect is due to the formation of a complex between $MnSO_4$, $Hg_2(ClO_4)_2$ and $AgNO_3$ which probably has Mn^{++} and Ag^{+} ions in equimolecular proportion, but the exact composition of this complex could not be established.

$K_2S_2O_8-Sn^{++}$ reaction :

The reaction gives erratic results when carried out in air or under CO_2 atmosphere. Hence it was conducted under N_2—atmosphere and all the reactants were dissolved in O_2-free conductivity water and stored in an atmosphere of N_2. The reaction is bimolecular, being unimolecular with respect to each of the reactants. Hydrochloric acid has little effect on the rate but K^{+}, Na^{+} and NO_3' ions inhibit the reaction in the order $K^{+} > NO_3' > Na^{+}$. In view of its similarity in behaviour to the $Fe^{++}-S_2O_8''$ reaction, the probable mechanism is :—

$$Sn^{++} + S_2O_8'' \xrightarrow[\text{determining}]{\text{rate}} Sn^{+++} + SO_4'' + SO_4' \qquad (1)$$

followed by

$$Sn^{+++} + SO_4' \xrightarrow{\text{fast}} Sn^{++++} + SO_4'' \qquad (2)$$

This mechanism may seem to be over simplified because the complex ion $SnCl_4''$, which is known to be formed in solutions of stannous chloride[4], may also react with S_2O_8'' and SO_4' ions.

Estimation of tin (II):

During the study of $Sn^{++}-S_2O_8''$ reaction, the several known volumetric methods for the estimation of tin (II) in dilute solution were found to be inaccurate. A modification of the iodometric method yielded most accurate results at all dilutions. In the modified present method a definite volume of a concentrated solution of potassium iodide is added to a known volume of standard copper sulphate solution. After the iodine is completely liberated, a known volume of stannous chloride solution is added to it and the unreacted iodine is titrated against sodium thiosulphate solution, standardized against copper sulphate solution, using starch as the indicator. The titration is carried out in CO_2 atmosphere and the solutions are prepared in freshly boiled conductivity water stored in CO_2 atmosphere.

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STUDIES ON THE ABSORPTION, EXCRETION AND UTILISATION OF MINERALS UNDER ACID AND ALKALI PRODUCING CATTLE FEEDS*

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An attempt has been made to establish a relationship between the acidity and alkalinity of urine, as induced by various dry and green roughages, and the assimilation of minerals in actively growing cattle. The first step in any such study is to examine the urine reaction under the feeding of different roughages. As a result of a comprehensive study it has been possible to identify roughages in general as (a) acid producing and (b) alkali producing.

It has been observed that the feeding of concentrates has a profound influence in lowering the alkalinity of urine even under the high alkali producing paddy straw. When they are supplemented over straw diet, in quantities necessary for growth (4·5 lb.), the alkalinity of urine is lowered nearly to half. Further studies on this line have shown that a similar change can be brought about even with as little as 500 gm. of high protein groundnut cake when fed with paddy straw and with 250 gm. of the cake in the case of jowar straw. The feeding of high protein green fodders in moderate quantities along with paddy straw showed practically no change in urine reaction.

In an attempt to alter the urine reaction from an alkaline to acidic condition an acidogenic agent like $CaCl_2$ has been used. It has been noticed that $CaCl_2$ in increasing doses tends to gradually decrease the alkalinity of urine. The most drastic change was effected by feeding a massive dose (150 gm.) of this salt, so much so that the highly alkaline paddy straw urine turned definitely acidic. This observation has afforded proof to the fact that urine reaction can be controlled at will by an external agency, as also that urine reaction is related to intestinal condition.

A study has also been conducted with both wheat and paddy straw to settle the controversy whether paddy straw causes diuresis or not. With identical Hariana calves the urinary excretion under paddy straw feeding was nearly four times more than under wheat straw, setting thereby the dispute at rest.

Experiments have been carried out to study whether mineral salts added to an exclusive diet of acid and alkali producing straws are utilised during the active period of growth in cattle. From the results obtained it appears that on a diet composed exclusively of straw which is otherwise favourable for the absorption of calcium and phosphorus in all respects, except the complex factor of acidity and alkalinity, the utilisation of dicalcium phosphate is practically nil. This could, however, be not said with absolute certainty that such is also the case when the diet has an acidic character, for at least under wheat straw feeding there is some indication that this mineral salt has partly been utilised.

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* Abstract of the thesis on which the degree of Doctor of Philosophy has been awarded by the Agra University.

In a fairly comprehensive series of experiments an attempt has been made to study the utilisation of minerals in actively growing Hariana calves under acid and alkali producing straws fortified with sufficient quantities of concentrates, to make the whole ration adequate for growth. Contrary to the observation made by earlier workers that the feeding of paddy straw invariably leads to negative calcium balance in adult animals, it has been found in the present investigation that such is not the case with young animals where the supplementation of concentrates over paddy straw diet lowers the alkalinity of urine nearly to half. In a condition like this some assimilation of calcium takes place. The principal lesson obtained from this study suggests that wherever paddy straw forms the basic roughage of cattle adequate amount of concentrates, required for the specific physiological function, along with $CaCO_3$ may sufficiently improve the balance of calcium and thus avoid disastrous consequences.

Unlike calcium the assimilation of phosphorus and magnesium does not appear to depend on the kind of feeding stuffs but is mainly governed by the intake level of these mineral elements.

The results indicate that when green feeds are supplemented over paddy straw and the intake of calcium is raised nearly two and a half times the N.R.C. level and that of phosphorus to the recommended standard, the defects of paddy straw feeding can be removed.

With a view to making a correct assessment of the availability of calcium from different acid and alkali producing straws a quantitative determination of the undigested roughage particles and the calcium locked up therein has been done. This residual roughage moiety excreted in the faeces has been coined by the author as the "faecal food residue". An exploratory method to determine the quantum of such residues has been evolved.

In young cattle the faecal food residue constituted about half of the total dry matter intake in the case of wheat and jowar straw but under paddy straw the faecal food residue was somewhat lower. Adult animals lost lesser quantity of feed dry matter in the form of the residue.

The calcium lost through the faecal food residue was lowest under acid producing wheat straw and increased with the rise in the alkalinity of straws. Supplementation of concentrates over straws was in general attended with a decrease in the loss of calcium through the residue but this effect was most marked in the case of acid producing wheat straw. These observations tend to show that acid producing wheat straw is capable of extracting more calcium from the faecal food residue than the alkali producing paddy straw.

The metabolism of copper has been studied in young growing Hariana calves under the feeding of acid and alkali producing straws. Incidentally, an attempt has also been made to determine the minimum copper requirement of these animals when straws constitute the basic roughages. It appears that the influence of acidity and alkalinity on the utilisation of copper is less marked, contrary to the observation made in the case of calcium. The requirement of copper for young growing Hariana calves may be set at about 40 mg. of copper per head per day for the margin of safety, though a positive balance may be fully assured at almost half this intake.

STUDIES ON THE EFFECT OF FATS AND PROTEINS ON CHOLESTEROL METABOLISM*

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Summary and Conclusions

The effect of fats and proteins on serum and tissue lipids was investigated in rats. 'High portein diet fed' rats were used for the assay of fats and 'high saturated fat fed' rats were used for the assay of proteins. Butter and hydrogenated fats increased the serum cholesterol concentration in animals while mustard oil produced an initial fall followed by levelling up of cholesterol values. The rise in serum total cholesterol levels was mainly due to increase in ester cholesterol fraction. The cholesterol contents of beta lipoprotein was also raised. Phospholipid showed no change.

The most striking finding of the present study was a marked fall in serum cholesterol concentration in rats fed on 20% hydrogenated fat 40% Bengal gram.

In order to find out the hypocholesterolemic principle of Bengal gram, it was fractionated into (i) lipid portion and (ii) protein portion. Both these fractions were found to be equally effective regarding their hypocholesterolemic action.

The animals fed on Bengal gram showed an increased excretion of bile acids and L.B. positive sterols and on sacrificing at the end of study, the -SH- and coenzyme A content were found to be lowered. The protein fraction of the Bengal gram was especially effective in reducing the SH and coenzyme A content of liver. On the other hand the lipid part increased the fecal elimination of cholesterol end products without effecting the SH and coenzyme A content of liver. As coenzyme A is vital enzyme in the initial stages of cholesterol synthesis, it might be speculated from these observations that hypocholesterolemic effect of protein fraction is accomplished through diminishing endogenous synthesis of cholesterol and that of lipid fraction through excessive elimination of bile acids.

The hypocholesterolemic activity of proteins was found to be dependent on 'sulphur' containing amino acid. When quantity of 'sulphur' containing amino acid was changed either by increasing the protein content from 4% to 20% or by addition of 100 mg. of methionine daily to the diet, the serum cholesterol levels and SH group content of liver were increased significantly.

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* This is a summary of the Thesis submitted to and approved by the Agra University, Agra for the degree of Doctor of Philosophy in Biochemistry.

The effect of butter fat, mustard oil, mustard oil and butter and Dalda and mustard oil was studied in 40 schizophrenics. Butter significantly raised the serum cholesterol while mustard oil depressed it. The mixture of (Butter-Mustard oil) (Dalda-Mustard oil) kept the serum cholesterol levels at the basal level. These mixtures have very low content of polyunsaturated acid yet they depressed the serum cholesterol concentration—a finding not supported by the theories of Ahrens and Keys (1956).

Mustard oil and fat mixture both increased bile acid excretion. The excretion was more in deoxycholic acid fraction rather than cholic acid fraction. No specific mode of action was assigned to saturated fats.

Butter, mustard oil, Dalda and til oil each 100 gms. were fed in rotation for 10 human subjects and serum cholesterol and fecal bile acid were studied. When saturated fat like butter and Dalda were substituted for a low fat diet or replaced for unsaturated fats, raised the serum cholesterol while similar substitution of mustard oil and til oil depressed it. The depression in serum cholesterol was always associated with increased excretion of bile acid. L.B. positive sterols were not effected.

Bengal gram when fed to human subjects, increased excretion of bile acids and L.B. positive sterols with depression of serum cholesterol in only few cases.

STUDIES ON INFECTIOUS BRONCHITIS OF POULTRY*

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The present study was undertaken for the isolation and characterization of infectious bronchitis virus (IBV) from the respiratory tract of poultry and for determining the serological incidence of IB infection in the poultry on certain poultry farms of the State.

The materials used for the isolation of the virus were obtained from the dead birds sent from the College Poultry Farm in the Department of Pathology and Bacteriology, for routine postmortem examination. Pieces of trachea and lungs were collected from the birds which had respiratory involvements. Only two materials, one consisting of 17 samples from cases of chronic respiratory diseases (CRD) and the other consisting of eight samples from cases of pneumonia associated with egg peritonitis, were thoroughly processed in the chick embryos and from each material a viral entity resembling IBV could be isolated.

For initial isolation of the virus, nine to twelve day old embryonated chicken eggs from PPLO free flock of the Department of Pathology and Bacteriology were used. However, for subsequent embryo passages, eggs from the College Poultry Farm were used after antibiotic dipping in erythromycin solution. This was done to exclude the possibility of transovarian transmission of PPLO, as the College Poultry Farm is known to be highly infected with CRD and thus safe-guarding against the difficulties in the interpretation of the results. Allantoic cavity route of embryo inoculation was employed for the isolation of the virus.

The virus produced typical curling and dwarfing of the embryos upon allantoic cavity route of inoculation. The leg bones were deformed and the tarsal joints were curled. The size of the amnion and the amniotic fluid were reduced and the amniotic membrane was found to be tightly adherent to the embryo. In a small percentage of embryos wry-necks with lateral curvature were so observed.

The virus increased in virulence for the embryos with the subsequent embryo passages. Majority of the embryos died between two to three day postinoculation.

The virus at ninth embryo passage was found to be quite virulent for the chickens when inoculated intratracheally. The incubation period was one to four days and the duration of the symptoms was one to two weeks. About 33% of the inoculated chicks succumbed to the infection.

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* An abstract of the thesis submitted to Agra University in partial fulfilment of the requirements for the award of M.V.Sc. degree in Bacteriology (1964).

The virus was nonhaemagglutinating to chicken red blood cells, heat-stable at 56°C for fortyfive minutes, resistant to penicillin and streptomycin in the concentration of 10,000 units and 25 mg./c.c. respectively and was filtrable through Seitz EK filter.

The various implications of the isolation of IBV from the poultry and the necessity of carrying out extensive serological studies and occurrence of IB outbreaks in the poultry stock in the state of Uttar Pradesh, and also in other parts of the country, are stressed.

STUDIES ON PATHOLOGY OF FEMALE GENITAL TRACT OF POULTRY WITH SPECIAL REFERENCE TO EGG-PERITONITIS*

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For the last several decades the diseases of the female genital organs of poultry have been recognized as one of the major factors of low production, high morbidity and mortality among the laying flocks in several countries. The present study was undertaken to explore the various disorders of female genital tract of poultry and to conduct experimental studies to elucidate the role of *Escherichia coli* in the causation of egg-peritonitis, as there appears to be little work done on this problem in India.

The tissues for the studies were collected from 255 hens autopsied in the department during the year 1963-64. Out of 136 birds having significant gross lesions in genital organs, the tissues of 97 birds were examined histopathologically. Bacteriological examinations were undertaken wherever necessary. The deparaffinised tissue sections were stained with haematoxylin and eosin. Special staining techniques were followed to demonstrate connective tissue elements, Gram-positive and negative organisms and various stages of blood cells. The post-mortem records of poultry maintained in this department for the six years (1958-1963) were utilized to work out the incidence of disorders of reproductive organs. Eighteen laying hens of 12 to 14 months of age obtained from pleuropneumonia like organisms free flock of this department, sterile egg yolk and two *E. coli* cultures of serogroups 078:K80 and 08 isolated from a chick and hen that had died naturally from septicaemia and egg-peritonitis respectively were used in the experimental studies. The birds in Group I were inoculated intraperitoneally with 25 ml. of egg yolk and 0·1 ml. of 24 hours broth culture of *E. coli* each. Four birds in Group II were inoculated intraperitoneally 25 ml. of sterile egg yolk each and the four birds of Group III with 0·1 ml. of the same *E. coli* culture. The birds which died or sacrificed were necropsied. Gross and histopathological examinations of the tissues were conducted as usual.

During the six years (1958-1963) out of 984 birds examined the disorders of the female genital organs were found in 441 (44·8%) cases, which included 279 (28·3%) cases of egg-peritonitis. The incidence of these disorders in different years ranged from 13·2% to 67·2% and that of egg-peritonitis alone from 8·6% to 56·7%. The studies conducted during the year 1963-1964, on gross and histopathological examination of 136 birds showed egg-peritonitis

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* This is an abstract of the thesis submitted in partial fulfilment of the requirements for the degree of M. V. Sc. in Pathology of the Agra University in 1964.

9·8%, salpingitis 9·4%, oophoritis 14·9%, neoplasms of ovary and oviduct 10 5%, under developed and atrophied ovaries and oviducts 18·4%, persistant right oviduct 3·9%, egg bound 8·2% and internal laying 5·8%.

Twenty-five cases of egg-peritonitis on histopathological examination revealed nine acute, eleven subacute and five chronic cases of non-suppurative peritonitis. The acute peritonitis lesions showed desquamation of mesothelial cells, highly congested blood capillaries and thickened stroma having mild to abundant serofibrinous or fibrinous exudate heavily infiltrated with heterophils and some macrophages. Subacute peritonitis lesions had congested blood capillaries considerably thickened stroma having some serofibrinous exudate infiltrated with lymphocytes, macrophages and plasma cells with some proliferating fibroblasts. The chronic lesions of peritonitis revealed congested blood capillaries, thickened stroma and adhesions on the surface having abundant proliferating and mature connective tissue infiltrated with lymphocytes. The lesions observed in these natural cases resembled to the experimentally produced peritonitis lesions. Twenty-three of these had free yolk, eggs or egg contents in the abdominal cavity and were usually associated with oophoritis and salpingitis. *E. coli* organisms were isolated from eight cases. Out of 24 cases of salpingitis 17 revealed non-suppurative and 7 suppurative lesions. *E. coli* organisms were isolated from four cases and Gram-positive cocci were demonstrated in suppurative cases. From 38 oophoritis cases 19 had acute, 12 subacute and 7 chronic lesions of non-suppurative type. Nineteen of these cases were associated with peritonitis and salpingitis. *E. coli* was isolated from two cases.

Neoplasms of oviduct included lymphomatosis in 7 cases, fibroleiomyoma and leiomyoma in one case each. Ovaries revealed 11 cases of lymphomatosis and seven cases of granulosa cell tumours. Lymphomatosis cases revealed severe extravascular accumulation of lymphoblasts with several mitotic figures.

The under development and atrophy of ovary and oviduct of undetermined etiology was recorded in 47 birds. Fully developed persistent right oviduct with a length of 36·5 cm. was observed in a pullet alongwith nine other cases of persistent right oviduct in the form of cysts and tubes. Egg bound condition without significant lesions in the oviduct was found in 21 cases. Internal laying was observed in 15 birds. Twelve birds had sterile yolk in the abdominal cavity with no lesions in the peritoneum and the remaining three cases had eggs or egg contents in body cavity with lesions of peritonitis and salpingitis.

Experimental studies revealed severe gross and histopathological lesions of peritonitis, which in some cases were also associated with oophoritis and salpingitis. The lesions of peritonitis were as severe and similar as observed in natural cases of egg-peritonitis. The role of *E. coli* organisms and free egg yolk in the causation of egg-peritonitis have been postulated. The significance and implications of various disorders of the female genital organs resulting in low production, high morbidity and mortality have been discussed and possibilities for further work emphasized.

STUDIES OF SYNTHETIC RESINS AND THEIR APPLICATIONS TO LIGNOCELLULOSIC BUILDING MATERIALS*

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SUMMARY

From the earliest times wood has been a most important material of construction. But during the past fifty years inventions and industrial progress have brought it into increasing competition with metals, concrete, masonry and allied products. An important factor contributing to the decline of wood as a material of construction has been the real or assumed superiority of other materials under certain conditions of use.

The main drawbacks of wood as a material of construction are (1) its hygroscopicity and "working" with changes in moisture content; (2) its anisotropy which leads to splitting, cracking and warping; (3) the limitation of size and shape imposed on it by the size of the tree it comes from; and (4) its lack of resistance to abrasion, weathering, chemicals, biological deterioration and to fire.

The advent of synthetic resins has helped wood to regain some of the lost ground and to extend its usefulness both technically and architecturally. Technically it is now possible to produce structural members of any size and shape from wood. Architecturally, aesthetic panels and structural elements to suit any requirements, or taste are possible. "Alloys" of different species of wood or of wood and other materials such as metal, glass and plastics are also possible through the use of synthetic resins.

Protective and decorative coating for wood are now largely based on synthetic resins.

It is clear from the foregoing that the study of synthetic resins is of great importance in furthering the rational utilization of the lignocellulosic resources of the country in the best interest of a growing economy.

Contributions both to the understanding of synthetic high polymers and to two aspects of their application to lignocellulosic building materials are presented in this thesis. The study is therefore extensive and covers and investigation of medium effects on the reaction mechanism of Friedel-Crafts polymerization of styrene by tin tetrachloride catalyst, the characterization in dilute solutions of copolymers of styrene and diallyl phthalate, the preparation of epoxy resins from low stage novolacs of phenol, p-cresol and cardanol and

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* Abstract of the thesis submitted for the degree of Doctor of Philosophy to the Agra University.

their application in metal to wood and wood to wood adhesive formulations, and the preparation of a phosphated polymer from cashew nutshell liquid and its application as a fire retardant for lignocellulosic building materials.

In order to study the medium effects on the cationic polymerization of styrene by tin tetrachloride, the rate of polymerization was determined in media of dielectric constant ranging from 2·2 to 29·7. Under the experimental conditions employed, the catalyst had no degrading effect on polystyrene, There was no evidence to show that the catalyst remains attached to the polymer. This observation has subsequently been confirmed by other workers.

The polystyrene produced was of relatively low molecular weight, the degree of polymerization being in the range 7 to 23. The degree of polymerization showed hardly any change with conversion. This is in agreement with results obtained by Williams. Tobolsky has subsequently advanced theoretical evidence to support this observation. When solvents which were not rigorously purified were used, an increase in the degree of polymerization as well as an induction effect was observed. The increase in degree of polymerization with conversion observed by some workers is considered to be due to the presence of impurities in the reaction mixture.

It is known that polar solvents favour the formation of polar products. Cationic polymerization which proceeds by an ionic mechanism should therefore be favoured by high dielectric constant media. A marked acceleration of polymerization was observed. Comparison of the results with those obtained by Pepper shows that the rate of Polymerization of styrene is many times greater in mixtures of carbon tetrachloride and nitrobezene than it is in mixtures of benzene and nitrobenzene of the same dielectric constant. This difference in reaction rates points to possible cocatalytic role of solvents.

Reproducibility of the reaction rate experiments was good irrespective of the prevailing relative humidity. Small amounts of water did not affect the rate whereas larger amounts depressed it. If water is the cocatalyst in this polymerization, its functions are fulfilled by a bare minimum of it.

The general electrostatic effect of dielectric constant is very significant as shown by a 1400-fold increase in overall rate of polymerization. However, the corresponding increase in molecular weight is only 2·8 times. A high dielectric constant favours the initiation reaction which produces ions but does not appreciably affect propagation reaction. It will slow down an ion neutralization type of cessation reaction, but favour proton splitting. However, the marked dependence of overall rate on dielectric constant is an indication that ion neutralization mechanism is applicable in the present case. This evidence supports the theory of Evans and Polanyi.

The effect of dielectric constant (D) on the overall reaction constant k is given by $\text{link}=K-\frac{K''}{D}+K'\frac{D-1}{2D+1}$ where K, K', and K'' are constants.

A plot of lnk—K *versus* dielectric constant for different values of K′ and K″ gives curves of the same general type as the experimental curve. This qualitative agreement is significant.

Further evidence in support of termination by ion neutralization is given by the suppressing effect of chloride ions on rate of polymerization.

In the field of polymer characterization, a set of copolymers of styrene and diallyl phthalate were studied. These were isolated at different percentages of monomer conversion in a benzoyl peroxide catalysed system of styrene and diallyl phthalate in the molar ratio 6:1.

The molecular weight of the copolymers was found to increase with conversion. The number average molecular weight as determined by osmotic pressure measurement using Zimm-Myerson osmometers rose from $1{\cdot}199\times10^5$ at 8·6 per cent conversion to $2{\cdot}256\times10^5$ at 71·5 per cent conversion. Light scattering data obtained on copolymer solutions using visual instruments were plotted as $\frac{HC}{\tau}$ versus C lines, and the molecular weights calculated from their intercepts ranged from $9{\cdot}4+10^4$ to $18{\cdot}3\ \times10^4$. The copolymers, however, showed dissymmetry of scatter, the intrinsic dissymmetry being of the order of 2·5. It showed a tendency to rise with increasing per cent of monomer conversion. After correcting for dissymmetry, the weight average molecular weight obtained ranged from $3{\cdot}8\ \times10^5$ at 8·6 per cent conversion to $6{\cdot}3\times10^5$ at 71·5 per cent conversion. These figures are only to be considered as indicating the order of magnitude of the weight average molecular weight.

The apparent discrepancy between M_n and M_w shows that the copolymers are polydisperse in nature.

The intrinsic dissymmetry permits the determination of the largest average extension of the copolymer chains in solution. Assuming that the copolymers are present as randomly coiled chains, as vinyl polymers usually are, this value is of the order of 2500 Å, showing thereby that the copolymer chains are considerably extended in solution.

The Flory-Huggins solvent-solute interaction constant, μ, was determined both from osmotic pressure and light scattering data. This constant as well as the slope A_1 of the lines from which it is calculated indicate the extent of interactions in solution. The value for A_1 increases and that for μ decreases with increasing conversion of monomer. This indicates an increase in interaction, or increasing solubility, with conversion. This can be explained on the basis of the less reactive monomer, diallyl phthalate, accumulating in the reaction mixture with the result that the polymer formed towards the end will contain more of it. Diallyl phthalate units are more soluble in methyl ethyl ketone than styrene units, The copolymer produced later in the polymerization reaction has, therefore, greater affinity for the solvent than that produced earlier. The positive values for $(0{\cdot}5-\mu)$ indicate that the copolymer and solvent are miscible in all proportions.

From viscometric and molecular weight data the value for Huggins' constant k_1 and the exponent a in Mark-Houwink equation were calculated. These values lend support to the conclusions arrived at from A_1 and μ.

In the field of application of polymers, attention was directed first to adhesives. Modern synthetic resin adhesives, have made it possible to combine wood with metals, thereby increasing the usefulness of both. Phenolic resins used in conjunction with thermoplastic or elastomeric polymers give excellent wood to metal bonds but the high temperatures required for bonding create certain problems. Epoxy resins can bring about room temperature bonding and it was desired to prepare synthetic resins and to formulate suitable adhesive from indigenously available raw materials.

An epoxy resin of epoxide value 0·35, was prepared from a low stage novolac which was essentially a mixture of dihydroxydiphenyl methanes. Its suitability for formulating structural adhesives was determined. To secure room temperature curd, ethylene diamine hardener was employed. Zinc dust, aluminium oxide and asbestos fillers were used to mitigate the influence of the difference in thermal expansion coefficients of metal and wood. An epoxy resins (epoxide value 0·28) from low stage p-cresol novolac was found to be a suitable plasticizer. The final adhesive formulation consisted of 100 parts of epoxy resin from phenol novolac, 10 parts of epoxy resin from p-cresol novolac 6·25 parts ethylene diamine, 50 parts zinc dust or aluminium oxide (or 10 parts asbestos), and a sufficient quantity of a 75:25 mixture of acetone and ethyl acetate to obtain an adhesive mixture of satisfactory working consistency. Wood to wood and wood to aluminium lap joints of 6·45 sq. cm. shear area prepared with the adhesives showed nearly complete failure in wood when tested to destruction in tension.

The excellent compatibility of epoxy resins to other thermosetting resins, and their toughness point to the possibility of their use as plasticizers for the more brittle phenol-formaldehyde resins.

Further, the epoxy group is capable of entering into reaction with hydroxyl groups invariably present in resol type resins. Low molecular weight epoxy plasticizers thus become integral parts of the resin they plasticize.

The epoxy resin from low stage novolac was used as modifier for hot setting phenol-formaldehyde resin in wood to metal adhesive. The resulting joints showed failure almost entirely in the wood when tested to destruction in tension. Unmodified phenolic resins joints delaminated on working.

Epoxydatedacardanol with its bulky 15 carbon side chain, and epoxydated cardanol-formaldehyde condensate were also tried as modifiers for phenolic adhesives. The former did not prove as satisfactory as the latter.

The bonding of wood to metal by epoxy resins is carried out in two stages. The metal, after it has been degreased and pickled, is primed with the adhesive and the primed metal is bonded to wood in the second stage of the operation.

The epoxy resin was replaced in the second of these stages by room temperature resorcinol-formaldehyde, and high temperature phenol-formaldehyde resin adhesives. The results, which were quite satisfactory, showed the compatibility of epoxy resin from novolac with these adhesives.

Commercial cashew nut shell liquid, which may be considered to be a mixture of m-pentadecadienyl phenol and 5-pentadecadienyl resorcinol, can function as a "carrier" for the combustion-inhibiting phosphate radical. These substances are highly reactive by virtue of their phenolic and unsaturated character.

Phosphated resins containing up to about 12 per cent phosphorus was obtained by heating together cashew nut shell liquid and orthophosphoric acid in appropriate proportions. The resin was characterized as an acid hydrogen phosphate which holds considerable proportions of phosphoric acid as a complex which is highly resistant to leaching by water. Further, on reacting the resin with an aldehyde such as paraformaldehyde, a hardened resin was obtained which resisted the leaching out of phosphoric acid even more tenaciously.

The phosphated resin was used both as a fire-retardant impregnant and as a fire-retardant coating for lignocellulosic building materials. Resin impregnated mango wood containing 1·3 per cent phosphorus showed a weight loss of only 26 per cent, when tested in a fire tube apparatus. The resistance of the treatment to leaching was not high because of the polar nature of wood constituents.

The phosphated resin is particularly effective as a fire-retardant coating. A mixture of 100 parts resin (3·8 per cent phosphorus) and 12·5 parts paraformaldehyde dispersed in a solvent when applied to wood and other similar materials forms a hard film which increases their resistance to taking fire considerably. In the fire tube test, coated specimens lost only 15 per cent weight even after doubling the duration of application of flame. Continuous leaching in running tap water for periods upto 2 months did not impair the efficiency of the coating.

The addition of brominated cashew nut shell liquid to the phosphated resin results in suppression of flaming and loss in weight in the fire tube test. The duration of after flaming decreased from 65 seconds to 2 seconds as the proportion of brominated liquid was raised from zero to 66·7 per cent in the coating.

Intumescent agents can also be successfully incorporated in the coating.

A fire-retardant coating of high efficiency and excellent resistance to leaching can be developed from phosphated resin of suitable phosphorus content by compounding it with halogenated liquid and intumescent agents.

STUDIES ON THE MORPHOLOGY AND PHYSIOLOGY OF RHYNCHOBDELLA ACULEATA BLOCH*

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GENERAL SUMMARY

Our knowledge of the family Mastacembelidae is very meagre. The only description available is that of Day (1878) who described briefly the external characters and geographical distribution of the members of the family. Other references include, Regan (1912) and Gregory (1933) on the skeletal peculiarities of the family, Mitra and Ghosh (1931) on the anatomy of the families of Opisthomi, Bhargava (1953) on pseudobranch of the family Mastacembelidae, Sufi (1956) on the fishes of the family Mastacembelidae, and Nagar and Khan (1958) on the morphology and histology of alimentary canal of *Mastacembelus armatus*.

With the idea of bringing out a comprehensive account of the anatomy of the bony fish and to complete the knowledge of the family, the investigations on the morphology and physiology of the common fresh water eel, *Rhynchobdella aculeata* (Bloch) was taken up under the guidance of Dr. V. P. Agrawal, Head of the Zoology Department, D. A. V. College, Muzaffarnagar, on which practically no work has been done so far. The investigation is spread over fourteen chapters, each dealing with one system of the fish. Each chapter comprises of a short resume of the previous work, an account of the morphology of the fish, and the discussion on the findings in the light of previous literature. The references have been given separately at the end, and are arranged alphabetically.

Chapter I deals with the systematic position of the fish. The classification is taken on the lines suggested by Day (1878). Salient characters of the various subdivisions have been stated and the diagnostic key of the family Mastacembelidae and the genera *Rhynchobdella* are given. While tracing the history of *Rhynchobdella*, it was found that the name *Macrognathus* was given earlier and so it has been suggested that the name *Macrognathus* should replace the commonly used name, *Rhynchobdella* for this fish. In the end of this chapter distribution of the fish has been given.

Chapter II deals with the different techniques and the methods employed at different stages of the present investigations.

Chapter III deals with the external features of the fish. The body of the fish is elongated and eel-like. Head is longer than broad, and is produced anteriorly into a trilobed snout which is admirably adapted for burrowing. The colour of the body is dark dorsally, light laterally while ventrally it is pale yellow. At the base of the second dorsal fin dark ocelli are found with light edges. The caudal fin is short which is in conformity with the views of Norman (1931) who described that in all eel-like fishes the caudal fin is either very much reduced or altogether absent.

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* Abstract of the thesis submitted for the degree of Doctor of Philosophy to the Agra University.

Chapter IV deals with the integument and the scales. The integument is scally and richly glandular. The mucus cells are distributed profusely, either isolated or in groups, throughout the depth of the epidermis. The dermis is distinguishable in the upper stratum laxum and lower stratum compactum. The chromatophores form an uncontinuous layers in the stratum laxum below the basement membrane. The chromatophores were also observed deep in the dermis which is rare amongst teleosts. Scales are only of cycloid type and are longer than broad with their margins being scalloped in varying degree. The narrow nature of the scales may be a modification necessitated by their burrowing habits.

Chapter V includes the description of the endoskeleton of the fish. About a dozen skeletons, a few alizerine transparencies were prepared for the present study. The characteristic features of the endoskeleton of the fish are as follows:

1. The skull is very long; it is broad at the posterior end and tapers anteriorly. It contains no ridges and crests on the upper surface.
   - (*a*) The ethmoid is elongated, plate-like and extends behind upto the 1/3rd of the frontals. It separates the two nasals mesially and forms a vertical septum between the nasal cavities.
   - (b) The lateral ethmoids fuse mesially.
   - (c) The prevomer is long; it is articulated anteriorly with the ethmoid while posteriorly it runs in the groove of parasphenoid on the ventral side.
   - (d) The large frontals are suturally joined with each other posteriorly, while anteriorly, they are separate. The frontal ridge hangs downward and articulates with the pleurosphenoid.
   - (e) There is no basisphenoid and orbitosphenoid.
   - (f) The parietals are separated by the supraoccipital.
   - (g) The parasphenoid is very long and extends from the prevomer upto the basioccipital. Postero-dorsal margins of parasphenoid bear short lateral expansions.
   - (h) The orbital ring is unossified. However, the infraorbital branch of the lateral line canal is present in the dermal tube. Lacrymal is well developed.

(i) The opisthotic is absent; the pterotic, the sphenotic, the prootic and the epiotic are present. Prootic is long and bears facet postero-dorsally, which take part in the formation of deep facet for the reception of the anterior condyler head of the hyomandibular.

(j) The supraoccipital, basioccipital and two exoccipitals are present. The exoccipitals enclose the foramen magnum completely.

(k) The premaxilla is formed of twenty-two plates, bearing minute, pointed teeth. Maxilla is attached by ligaments to ethmoid. Palatine is narrow and is immovably united with the ethmoid, vomer and parasphenoid.

(l) The endopterygoid is movably articulated with the lateral ethmoid outside the palatine.

(m) There are only two basibranchials; the third one is replaced by a cartilaginous plate. The third hypobranchial bears an oval patch bearing teeth at the proximal end. Five pairs of ceratobranchials are found, the fifth one is slightly flattened and is toothed. Three pharyngobranchials are toothed.

(n) The opercular, subopercular, interopercular are present. A spinous projection is given out from the antero-dorsal margin of the subopercular which runs in between the opercular and inter-opercular.

2. The vertebral column of the fish includes 66 to 96 vertebrae with 30 to 40 trunk and 36 to 51 caudal vertebrae. The centrum of the first vertebra is convex infront, fitting into a cavity of the skull. First seven vertebrae have flattened spines.

(a) The basapophysis arise as dorso-lateral projection in the anterior vertebrae and then shift ventrally to form the haemal arches in the posterior vertebrae. In the first seven vertebrae, the ribs are attached in the sockets of the centra and are after attached to the basapophysis.

(b) There are four hypurals; the fourth one is distally subdivided into two unequal halves. The radials are three, the first belongs to the penultimate vertebra while the remaining two belong to the last caudal vertebra.

3. The pelvic fins and the pelvic girdles are absent. The pectoral girdle is attached by a ligament to the 3rd or 4th vertebra. The hypercoracoid is perforated. The hypocoracoid has posterior coracoid process. There is no mesocoracoid. There are four radials, two on the hypercoracoid and two on hypocoracoid.

Chapter VI deals with the aquatic and aerial respiration of the fish. Day (1878) has commented, "*R. aculeata* becomes drowned if placed in water when not able to reach the surface, apparently requiring to respire air directly".

This statement made the author interested to perform certain experiments. The interesting points of the respiratory system of this fish include :

1. The fish is habitually water breather, but can utilise the atmospheric air in exceptional circumstances.
2. The aquatic respiration is performed by four pairs of holobranchs, which are of usual type.
3. There is no pseudobranch in this fish though Bhargava (1953) reported its presence in the embryo and adult of *Mastacembelus*.
4. The "drowning experiments" were undertaken; and it was found that the fish under study can survive outside the water for prolonged periods.
5. There is no accessary respiratory organs in this fish as were observed by Day (1868) in *Clarias*, *Heteropneustes* and *Ophiocephalus*. Some experiments were undertaken to establish the aerial respiration in the fish.
6. As the bucco-pharyngeal epithelium shows no abnormal vascularisation, the author is of the opinion that the aerial respiration in this fish is performed by gills. The utilization of gills for aerial respiration, though rare among fishes is also reported by Hora (1935) in *Mystus gulio*.
7. The flow of air is maintained over the gills, as was observed by Hora (1935).

Chapter VII comprises the account of the morphology and histology of the air-bladder.

1. Air-bladder of *Rhynchobdella* is elongated, extending from septum transversum to the hind end of the body cavity.
2. The pneumatic duct is closed and the bladder does not take part in the aerial respiration. It acts only as the hydrostatic organ.
3. Histologically, the wall of air-bladder consists of the external, tunica external and internal, tunica interna.

Chapter VIII deals with the anatomy histology and physiology of the alimentary canal of *R. aculeata* in detail. The important features can be summarised as below :

1. The fish under study is predominantly carnivorous, feeding mainly on small worms and crustaceans. In starved conditions, the fish could also be fed on aquatic vegetation.
2. The alimentary canal of *Rhynchobdella* is a straight, comparatively small tube. Both mouth and anus are ventral in position. The oesophagus passes insensibly into the stomach which is clearly divisible into a tubular cardiac and globular pyloric stomach. The intestine

is separated from the rectum by an external constriction. The exit of the intestine into rectum is provided with ilio-rectal valve. The intestine is produced, anteriorly into a pair of intestinal caeca. Liver is a uni-lobed structure covering the oesophagus and a part of the stomach. The pancreas of the fish is diffused with in and around the liver.

3. The upper jaw takes part in the formation of a trilobed snout, which bears a cartilaginous rod in its median lobe. It is well supplied with taste buds and mucus glands.
4. In the bucco-pharynx, a well marked maxillary valve is present which operates against the thickened muscular portion of the lower jaw.
5. The bucco-pharynx is provided with a large number of teeth on premaxillae, dentaries as well as on pharyngeal and horny pads.
6. The taste buds are found in the snout, bucco-pharynx, the maxillary valve and the tongue. The gastric glands are present in the cardiac stomach but are wanting in pyloric stomach.
7. Histologically, the intestinal caeca are similar to the intestine and in the present description have been termed as the intestinal in place of the pyloric caeca.
8. The mucosa of the intestine and rectum contains three types of cells, the mucus cells, the absorptive cells and the wandering cells.
9. The pH of the different parts of the alimentary canal varies from 6·25 to 6·85 in the normal feeding fishes and 6·25 to 7·1 in the starved fishes.
10. A study of the qualitative estimation of the digestive enzymes shows that the liver alone secretes most of the digestive enzymes. The lipase and proteases are very active. The gastric glands of stomach seem to produce only the proteases. No enzymes are secreted in the oesophagus, and rectum.
11. The enzymes secreted by the liver are passed on to the intestine where they react on the food.

Chapter IX deals with the somatic musculature of the fish from the functional point of view especially its locomotion. In this fish, locomotion appears to be some what Anguilliform as suggested by Breder (1927). Pectoral fins help the fish in changing the direction during movement, the median fins are the seat of localised undulation while the caudal fin plays practically no role in locomotion.

Chapter X includes the description of the heart, the different arteries, and the veins.

1. The heart is formed on the general teleostean pattern. However, the characteristic features can be summarised as below :
   (a) The sinus venosus is rather small and has a pair of sinu-auricular valves.

(b) The auricle is proportionately large, with four auriculo-ventricular valves, one pair being larger than the other.

(c) The ventricle is thick walled structure with a narrow lumen; it is provided with a pair of ventro-bulbar valves.

(d) The bulbus arteriosus is thick walled with swollen base; its trabeculae fill most of its lumen.

2. Four pairs of afferent branchial arteries are given out from the ventral aorta. The third and fourth afferents arise through a common stem from the swollen part of the ventral aorta. The first and second pairs are of the usual type.

3. The first and second pairs of efferent branchial arteries take part in the formation of cephalicus, while the third and fourth pairs open by a common trunk in the dorsal aorta immediately below the cephalicus.

4. Right and left subclavians arise from the junction of the first pair of supra-branchial arteries.

5. The coeliaco-mesenteric artery arises from the dorsal aorta, just behind the subclavians; it immediately divides into three branches. These branches supply blood to the different parts of the digestive system, air-bladder and spleen.

6. Gonadial artery arise from the posterior region of the dorsal aorta, it bifurcates to supply the two gonads.

7. The anterior cardinal vein of only left side persists. Paired infra juglar veins are present. The ductus cuvieri are two large veins which lie transversely infront of the septum transversum.

8. The hepatic vein, bifurcates after septum transversum, forming two long, spaceous hepatic sinuses.

9. The posterior cardinal of the right side persists and into it, opens the right renal portal vein.

10. Only right renal portal vein persists in continuation with the caudal vein.

The absence of one anterior cardinal and one posterior cardinal vein and the elongation of the hepatic veins are correlated with the elongation of the body.

Chapter XI deals with the study of brain, spinal cord and the distribution of cranial and spinal nerves. These though conform the typical teleost plan in general, yet show some variations.

(a) The optic lobes of the brain are better developed. The cerebrum and the olfactory lobes are paired, the latter lying anterior to the former. The cerebellum is not very well developed.

(b) There are ten pairs of cranial nerves which follow the general teleostean plan with only minor differences. The paired optic nerves do not form a true optic chiasma but simply cross each other ventrally. The fifth and seventh cranial nerves form the trigemino-fascial complex at their base.

(c) The spinal nerves of the fish vary according to the number of vertebrae. These are paired and can be arranged in two groups, those which originate through the common exit of the vertebrae, while others include those originating though the separate exits of the vertebrae. The former includes first 29 and the last 27 pairs of spinal nerves, while the latter group includes all the spinal nerves of the middle region.

Chapter XII deals with the sense organs of the fish. In this chapter the olfactory organs, the eyes, the internal ear and the sensory cephalic canals have been described. These conform the typical teleost plan in general. The olfactory organs are elongated and the anterior and posterior nares are situated wide apart.

Chapter XIII deals with the description of the urino-genital system which can be summarised as follows :

(a) Due to the elongation of the body and shortening of the body cavity, the kidneys extend almost throughout the length. The two kidneys are fused posteriorly and separate anteriorly.

(b) The non excretory part (the head kidney) is continuous with the excretory part (the trunk kidney).

(c) The maceration preparations of the kidney reveals that the trunk kidney also contain the aglomerular tubules in addition to normal glomerular tubules.

(d) The gonads are long and unequal in size, the left one being longer than the right, and extends even upto the oesophagus. The two ducts of the gonads unite before opening into the neck of median urinary bladder.

(e) Though the urino-genital papilla is present in both the sexes, yet it does not show any sexual dimorphism.

(f) The breeding season of the fish ranges from June to August. The sex composition of the samples collected during the different months of the year suggests that females are more in number during all the different months of the year.

Chapter XIV deals with the bionomics of the fish. In this chapter, light has been thrown on the hibernation and aestivation. As regards the economic importance of the fish, *Rhynchobdella* is not much admired as food, yet it is eaten in good number by poor people. This chapter also includes the systematics of the family Mastacembelidae.

MORPHOLOGICAL STUDIES IN *PLANTAGO*[*]

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The genus *Plantago* L., belonging to the family Plantaginaceae, is of high medicinal and other economic and commercial value. The systematic position of the family is much disputed. In spite of the controversial position of it's family as well as economic importance of *Plantago* practically no detailed morphological and embryological investigations have been carried out in this genus. Therefore, a detailed study of external morphology, vegetative anatomy, floral biology, floral anatomy, embryology and seed structure of six *Plantago* species (*P. amplexicaulis, P. coronopus, P. lagopus, P. major, P. ovata*, and *P. pumila*) has been made.

All *Plantago* species under investigation, are herbaceous with strong tap root system excepting *P. major* where a bunch of adventitous roots develop. The stem in *P. coronopus* and *P. major* is highly condensed with radical leaves; in *P. amplexicaulis, P. lagopus* and *P. ovata*, it is less condensed with spirally arranged leaves. *P. pumila*, on the other hand, possesses stem with distinct nodes and internodes having opposite and decussate leaves. Leaves are either ovate (*P. major*), linear-lanceolate (*P. amplexicaulis, P. ovata*), spathulate (*P. lagopus*) or acicular (*P. pumila*); margin is entire excepting *P. coronopus* which has highly pinnatisect leaves. In all species, the leaf possesses varying number of parallel, convergent type of veins.

Flowers are arranged in a spike which is borne at the tip of a long, axillary leafless stalk. Flowers are bracteate, sessile, complete, tetramerous, actinomorphic, hermaphrodite and hypogynous. There are four, free sepals excepting *P. lagopus* whose anterior pair is fused. The four petals, which are united, alternate with sepals. There are four epipetalous stamens bearing versatile anthers. The bicarpellary, bilocular, syncarpous ovary possesses varying number of ovules on axile placenta. The long, feathery style has a diffused stigma. Fruit is a pyxidium.

Germination of seed is epigeal. The seedling bears two long, acicular, green cotyledons. The meristematic initials of root apex cut off cells in three directions. The epiblema (or epidermis) owes its origin to the innermost layer of the root cap. The root is tetrarch in *P. amplexicaulis* and *P. ovata*, while it is diarch in the rest. In species having tetrarch roots, the change from radial symmetry of vascular bundles to collateral, endarch ones is brought about at the base of the cotyledons which receive three bundles forming a trilacunar node; while in *P. coronopus* and *P. lagopus*, it happens within the hypocotyl itself; the cotyledon, in these species, shows unilacunar condition. In *P. coronopus* the cotyledonary bundle remains undivided but in *P. lagopus*, it sends out two laterals.

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[*] Abstract of the thesis submitted for the degree of Doctor of Philosophy to the Agra University.

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The leaf is dorsiventral (*P. major*) as well as isobilateral. Each vein is traversed with only one bundle which is surrounded by a distinct sheath. The ranunculaceous type of stomata are found flush with the epidermis on both the surfaces of the leaf. The hairs are glandular as well as non-glandular. The gland is one-celled in *P. pumila* and two-celled in *P. amplexicaulis* and *P. major*.

Secondary growth in stem occurs in all the species. The vascular tissue forms a continuous ring in *P. pumila* only ; in others it is broken by the overlapping of leaf traces which are more marked in *P. coronopus* and *P. major*. In *P. amplexicaulis*, *P. ovata* and *P. pumila*, the secondary xylem and peri-vascular ring consist of lignified cells only, while in others the secondary xylem possesses lignified as well as parenchymatous cell and the peri-vascular ring is non-lignified. Wood consists of vessels, tracheids, fibre-tracheids and libriform fibres. Simple perforations are present at the end walls which are either truncate or beaked. A distinct endodermoid layer and hollow pith are seen in *P. pumila* only. An ill-defined periderm is present in *P. coronopus* and *P. major*. The vascular supply to leaf in *P. coronopus* and *P. pumila* forms one trace unilacunar node. In *P. ovata* the node is trilacunar, while in *P. lagopus* and *P. majar* it is multilacunar. There appears to exist a definite relationship between the type of node and the size of leaf and its base.

The secondary growth is profuse in root. The solid cylinder of secondary xylem either consists of lignified cells only or both lignified and parenchymatous cells (*P. coronopus* and *P. major*). Periderm is present in all the species.

The floral biology of *P. ovata* has been studied. The total time required for the bud to open is about 35 days. The bud passes through 5 distinct stages to blossom. Dehiscence of floral bud takes place from 7·15 a.m. to 5·0 p.m. but the peak period lies between 8·0 a.m. and 9·30 a.m. Anthesis occurs only after dehiscence. Pollen grains are mostly fertile. Flowers pollinated on the day of dehiscence and 1-, 2-, or 3 days after dehiscence usually yield fruits showing the duration of the receptive nature of the diffused stigma. Inbreeding is possible in *P. ovata*.

Floral anatomy, especially the bract supply, shows interesting features. The vascular supply to bract in *P. coronopus*, *P. lagopus*, *P. major*. and *P. pumila* forms one trace unilacunar node while in *P. amplexicaulis* and *P. ovata*, it forms a trilacunar node. In *P. major* it remains undivided throughout: in *P. lagopus*, it forms 7-8 laterals while in *P. coronopus* and *P. pumila* only two laterals are formed. Like the nodal structure of the stem, a definite correlation seems to exist between the bract size and the number of lacunae. Each sepal receives three traces with a common origin. In *P. lagopus*, however, the sepal trace remains undivided. The petal and stamen receive one trace each. Only three traces supply ovary, two normally oriented dorsal carpellary bundles and a central amphicribral, placental bundle. The placental bundle is totally consumed in supplying the ovules while the two dorsal bundles move on to the style where they run parallel up to its tip.

The anther wall is four-layered. At maturity only the epidermis and the fibrous endothecium are seen. The tapetum is of the secretory type and its cells usually remain uninucleate. Microspore mother cells divide simultaneously forming tetrahedral and isobilateral tetrads. The pollen grains are smooth, spheroidal, panporate and two-celled at the time of shedding.

Ovule is ana-campylotropous, unitegmic and tenuinucellate. The archesporial cell, which directly functions as megaspore mother cell, forms a linear megaspore tetrad of which the lowermost functions. The development of embryo sac conforms to the Polygonum type.

Fertilization is porogamous. Usually one pollen tube enters the embryo sac. The pollen tube is seen lying close to the egg even at the second or third stage of endosperm division.

Endosperm is of Cellular type. After the first transverse division of the primary endosperm nucleus, the micropylar chamber undergoes two successive longitudinal divisions at right angles to each other followed by a transverse one. This results in an upper tier of four cells that develop into four micropylar haustoria; the lower tier or the central chamber of the endosperm constitutes the main body of endosperm. The chalazal chamber of the endosperm, on the other hand, becomes binucleate and functions as chalazal haustorium. The micropylar haustoria in *P. amplexicaulis*, *P. lagopus* and *P. ovata* send out branches. From the chalazal haustorium of *P. lagopus*, there arise two enucleate branches that girdle round the endosperm and proceed up to the other end of the ovule.

The embryogeny conforms to the Onagrad type. Since it does not fit in with any of the variations of the Onagrad type, a new variation, *Plantago* variation, is suggested.

The two-layered seedcoat represents the endothelial and the outermost epidermal layer of the integument. Cells of the innermost layer of the testa become tangentially crushed and are found to be unhealthy excepting that of *P. amplexicaulis* where they remain healthy; cells of the outermost layer are large and mucilaginous.

The fruit consists of 2 seeds in *P. amplexicaulis*, *P. lagopus*, *P. ovata* and *P. pumila*, 5 in *P. coronopus*, and 7 in *P. major*. The colour, shape, size and weight of seeds vary in different species. In *P. major* the cotyledons are placed dorsi-ventrally, in others they are placed laterally. The amount of mucilage is comparatively more in the seeds of *P. ovata* than that of others. It occurs in the form of striations beneath the cell walls.

On the basis of early endosperm division and other embryological characters, Plantaginaceae appears to be more closely related to Scrophulariaceae than to Primulaceae, Oleales, Polemoniaceae, Verbenaceae, Labiatae, Acanthaceae and Rubiaceae. Contrary to previous views it seems quite justifiable to include the family within Tubiflorae instead of raising it to a separate order Plantaginales.

STUDIES IN THE EPIDEMIOLOGY, CYTOLOGY AND CHEMOTHERAPY OF *BAJRA* AND LENTIL RUSTS*

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Synopsis

The thesis comprises investigations on the epidemiology, cytology and chemotherapy of the rusts of pearl millet or *bajra*† (*Pennisetum typhoides* Stapf and Hubb.) and lentil (*Lens culinaris* Medic.), caused respectively by *Puccinia penniseti* (Zimm.) and *Uromyces fabae* (Pers.) de Bary. Part I deals with the rust of *bajra* and Part II with that of lentil.

Part I

Studies were conducted in local fields of *bajra* during *kharif* (July-Oct.), 1961 and 1962 to gather information on the optimum requirements of temperature and relative humidity in relation to rust development. These factors were recorded using thermohygrographs. The disease intensity was calculated on a modified Cobb's scale, the maximum being recorded at those temperatures and relative humidities which range from 22 to 26° C and 72 to 75 per cent respectively. The observations were taken during two seasons and it was noted that the deposit of dew on the leaf surface was an important factor in determining disease intensity.

The rust infection was also found to be influenced by the phyllosphere mycoflora which forms a microbiological complex, comparable to that seen in the rhizosphere. Uredospore germination and rust incidence were studied in relation to the myco-organisms found on the surface of *bajra* leaves. *Chaetomium globosum* Kunze and *Fusarium oxysporum* Schlecht. ex Fr. were responsible for almost cent per cent inhibition of uredospore germination and showed the maximum suppression of disease symptoms on the host seedlings. The results indicate that this is an inviting field of study and infuse fresh hope to the biological control of rusts diseases.

The importance of physiologic races in rust epidemiology is well known. Hitherto, physiologic specialization in *Puccinia penniseti* was only suspected and the discovery of homothallism and functionless pycnia by Dalela and Sinha ruled out the possibility of the formation of physiologic races by hybridization. As a result of the present study of reactions of 12 rust samples on 50 host varieties and stable ecotypes, definite indications are forthcoming that physiologic races of the pathogen do exist. It is suggested that the origin of the races may be sought in heterocaryosis, mutation, irregularity in nuclear distribution at the time of sporulation, unequal exchange of cytoplasm between biotypes and somatic combinations. The presence of morphologic forms of teliospores based on biometrical analysis further supports the existence of physiologic races. In the present investigation, three distinct categories of teliospores were found. Morphologic forms in the uredospores have been reported earlier too. Teliospores also showed teratological variations.

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* Abstract of the thesis submitted for the degree of Doctor of Philosophy of the Agra University.

† Known as *Cunbu* in South India.

Collateral hosts play an undisputed role in causing rust epidemics. Susceptibility of 8 species of *Pennisetum* to *Puccinia penniseti* was tested. It was found that *Pennisetum nigratum*, *P. pycnostachyon*, and *P. glacum* are highly susceptible, and the remaining species show reactions ranging from immune to resistant.

A successful germination of spores of the pathogen is an important prerequisite for infection. In this investigation, self-inhibition of uredospore germination has been demonstrated. An analysis of the nature of the inhibitory principle revealed that the substance is volatile, thermostable and its maximal peak of absorption lies in the ultra-violet range. The effect of the inhibition was nullified when 20% silver nitrate, 0·06 M ammonia and 1·4% acetone solutions were placed in the germinating vessels. The properties of the inhibitory substance fully resemble those of trimethylethylene. Self-stimulation of uredospore germination was noted when the inhibitor solution was used in germination studies, after its exposition to the atmosphere and centrifugation.

Earlier cytological work on the rust relates to the aecial stage only. In the present studies cytological events during teliospore germination and basidiospore formation have been described and observations made on the division of the diploid nucleus of the teliospore, meiosis, chromosome number and nuclear division in the basidiospore. The teliospore on germination produces a three-celled promycelium in which the upper two cells containing nuclei, appear functional, while the lower most cell is without a nucleus and functionless. Each of the two cells normally gives rise to a quadrinucleate basidiospore. The division of nuclei in basidiospore may continue till there are eight to ten nuclei in it. Presumably all the nuclei but one degenerate before the basidiospore germinates to produce a monocaryon mycelium. The haploid chromosome number is five, four chromosomes arranged in two pairs of different sizes, leaving a single smallest chromosome solitary. There appears to be no relationship between chromosome number and sex behaviour as claimed by some workers.

Dalela, working in this laboratory reported encouraging results on the use of certain chemicals on the inhibition of uredospore germination and also on the appearance of the rust on *bajra* seedlings. Further work along the same lines was presently conducted. Twentyone chemicals, including fungicides, plant growth-regulators, chelating substances and antibiotics were evaluated for causing inhibition of germination and those found effective were employed to test their efficacy in suppressing development of rust on the host. This study shows that by spraying *bajra* seedlings 24 hours before, or at the time of inoculations, with ziram, cupramar, ceresan, dithane S31 and dithane M 22 and O-phenanthroline, the rust infection is considerably reduced.

PART II

The studies on lentil rust (*Uromyces fabae* (Pers.) de Bary) cover investigations on host range, host substrate in relation to biometric variations, nuclear events in teliospore germination, haploid chromosome number, and possibility of chemical control.

Seven spp. of *Vicia* were found to be susceptible to the rust and can act as collateral hosts which are pretty important in the epidemiology of the disease. These hosts are *Vicia faba*, *V. hirsuta*, *V. biensis*, *V. tetrasperma*, *V. narborensis*, *V. gracilis*, *V. ervilia* and probably also some varieties of *V. sativa*. The possibility of variations in the pathogen, which is of importance in the disease syndrome, was studied on biometric basis. Two morphologic forms were recognized. These results provide material for further studies on physiologic specialization in this rust.

A cytological study on teliospore germination revealed the formation of a five-celled promycelium. The haploid chromosome number is four, confirming the earlier observations of Savile.

In the experiments on chemical control, ten chemicals representing the group of fungicides, plant growth-regulators, a chelating substance and an antibiotic were evaluated in the laboratory for their efficacy in inhibiting aeciospore germination and rust development. When seedlings of lentil were given foliar sprays of ziram, dithane M 22, cupramar and O-phenanthroline, 24 hours before, or at the time of inoculation, the disease was considerably suppressed. No control could be achieved when the spray was applied 24 hours after inoculation.

STUDIES ON THE OCCURRENCE OF VIRUSES IN THE RESPIRATORY TRACT OF POULTRY*

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The present investigation was undertaken with a view to study the occurrence of viruses (excluding Ranikhet disease and fowl pox) which might be associated with the respiratory diseases of poultry and indentify them on the basis of isolation in chicken embryos and serological studies.

Materials for the isolation of viruses from the respiratory tract included larynx, trachea, lungs and air sacs from birds submitted for routine postmortem examination and thirtytwo samples were processed for virus isolation out of one hundred thrityfour tissue samples collected. Materials were pooled into four lots, one from cases of chronic respiratory disease (CRD), two from cases of lung lesions associated with egg peritonitis and one from other lesions.

For virus isolation, the embryonated eggs either from PPLO free flock or from PPLO infected flock after dipping in erythromycin antibiotic solution, were utilised. Yolk sac, allantoic cavity and chorioallentoic membrane (CAM) routes were employed for inoculation of the materials. The virus like agents producing pock like lesions on the chorioallentoic membrane of embryonated eggs were issolated from each of the first three pooled samples.

All the strains of the virus were found to be non-haemagglutinating to chicken erythrocytes, heat susceptible at 56°C., for 30 minutes and resistant to penicillin (10,000 units/ml.) and streptomycin (25 mg./ml.).

The impression smears prepared from yolk sacs and CAM of embryos infected with the viral agents gave no evidence of Lovinthal-Cole-Lillie (L.C.L.) bodies suggestive of ornithosis. All the strains of the virus were not infective to mice by intracranial, intranasal and intraperitonial routes of inoculation.

Thirtyseven serum samples were pooled into seven groups and were forwarded to Dr. R. A. Bankowski of California University, U. S. A. for serological evidence against various respiratory viruses. All the 1:4 diluted serum samples were found to neutralize 80 plaque forming units (p.f.u.) of infectious laryngotracheitis (ILT) virus. The sera showed 10^3 to 10^5 or greater serum neutralization titres against infectious bronchitis (IB) virus. All samples were negative to the antibodies against psittacosis and Myxo-virus strain Y of

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* An abstract of the thesis submitted to Agra University in partial fulfilment of the requirements for the award of M.V.Sc. degree in Bacteriology in 1963.

Bankowski and Corstvet (1961). The antisera produced against the viral agent included in this study and forwarded to Dr. Bankowski neutralized 80 p.f.u. of ILT virus and was negative to other respiratory viruses. This confirms that this viral agent was similar to ILT virus.

The serological evidence of the existence of IB infection of poultry in this country has also been reported.

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